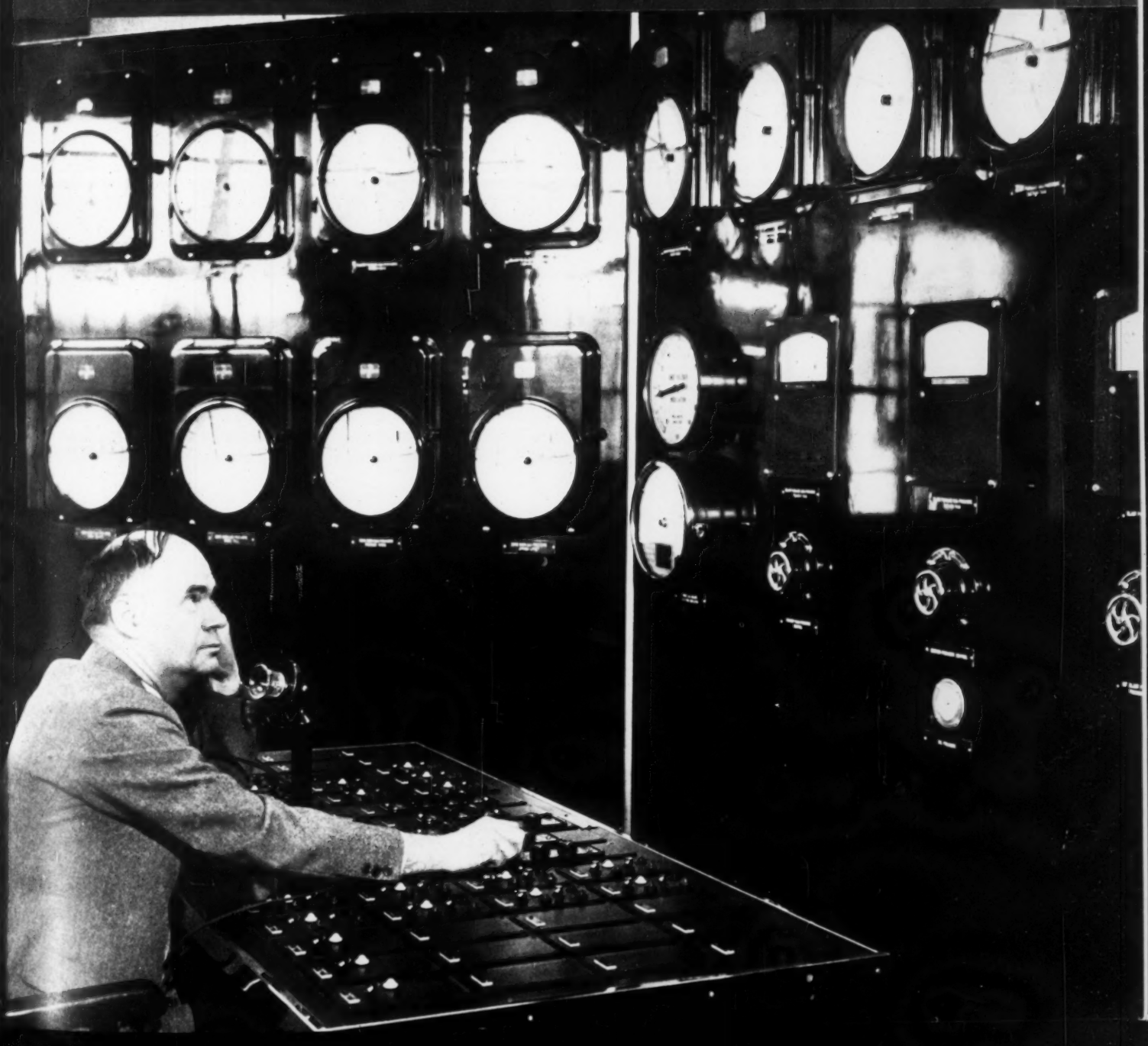
Instruments

THE MAGAZINE OF Measurement and Control

Vol. 11
APRIL
1938
No. 4



CELECTRAY
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SOLVED!
A Twenty Year Old Problem in Multiple Recording
The TAG announcement in March Instruments was real instrument NEWS for process engineers: the TAG Double Speed CELECTRAY Recorder with 5 second intervals between records—a 12 record round trip in 1 minute.
Today's TAG announcement is HEADLINE NEWS: TAG's STANDARD multiple point CELECTRAY Recorder curbed to record any place on the chart at fixed intervals less than the time required to traverse the chart.
Result: CELECTRAY gives you the speed of recording necessary for your particular application.
TAG DOUBLE Speed CELECTRAY Recorder 5 to 7 second intervals. TAG STANDARD CELECTRAY Recorder 10 to 14 second intervals or 30 second fixed intervals, either speed of printing as shown on the chart sections above can be obtained by a mere change of a single connection.
Rated on versatility only, these multiple point Recorders create special interest. Versatility in performance and rugged simplicity in design—the proved CELECTRAY principle of photoelectric detection of a light beam passing a "controlling edge." Ask for the whole story of these reliable instruments and learn how they improve uniformity of product and reduce operation costs.
C. J. TAGLIABUE MFG. CO.
Park & Nostrand Ave's., Brooklyn, N. Y.
TAG

HOW TO SAVE MONEY IN YOUR PLANT with Automatic Process Control

9 Years ago in Alabama Taylor Coordinated Instrumentation was working for Industry. Today in modernized and even more efficient form it is available for your plant. Send coupon for the Taylor Consulting Service

THE TREND toward the fully automatic control of entire processes may be recent. But the means for doing it are not new.

Nine years ago Coordinated Instrumentation as developed by Taylor Engineers began to operate in process industries.

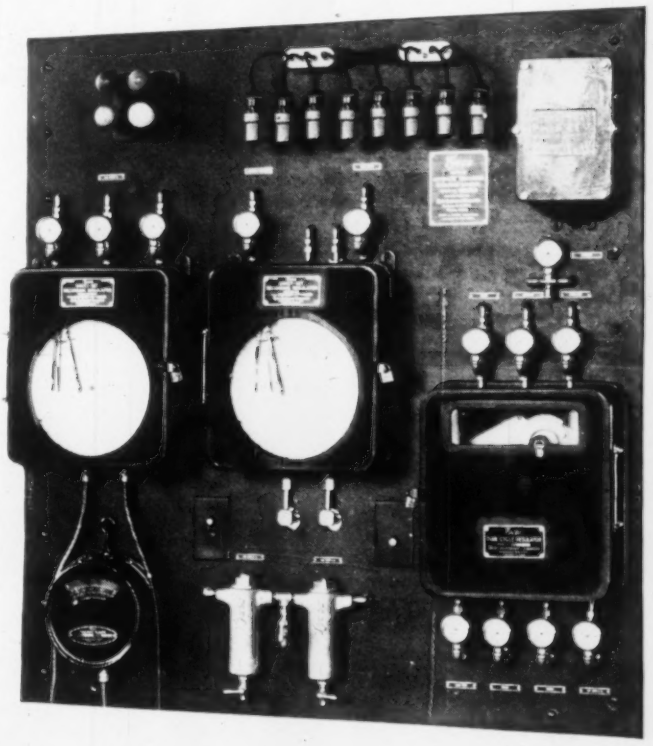
At that time twenty-six Taylor Systems of Control, illustrated by the panel board shown below, were designed and built for the Gadsden Plant of the Goodyear Tire & Rubber Company. Twelve more units were constructed for a tire and rubber plant in South America.

Ever since then, these thirty-eight systems have been automatically controlling time, temperature and pressure in curing all the tires made at these two plants. And since 1928 Taylor Systems of Coordinated Instrumentation have been helping to produce many products in rubber, brewing, textile, tobacco, food and other fields.

What is Taylor Coordinated Instrumentation? It designates process control in which two or more variables are controlled in a predetermined relation to one another. This includes installations all the way from a Single Taylor Time-Schedule Controller to a complex system in which several instruments are coordinated and interlocked to carry on completely an intricate process. The latter system is built around a Taylor Time-Cycle Controller, the complete master of a process cycle, which controls a series of operations according to a hard and fast schedule to produce a product of precise characteristics and qualities.

Taylor Coordinated Instrumentation guarantees reproduction of a processing schedule at any time—every time. It is one of the best assurances of uniform quality. It speeds the production flow. It practically eliminates waste and seconds. It saves money . . . cuts production costs. It increases net profits.

Taylor Coordinated Instrumentation is an investment whose returns exceed the money invested. Let us fit it to your needs in your plant. To get the services of engineers who know industry's problems and will help you apply this control to your processes, just fill out and send in the coupon. Taylor Instrument Companies, Rochester, N. Y. Plant in Toronto, Canada. Manufacturers in Great Britain—Short & Mason, Ltd., London, England.



IN 1928

Taylor began work in Coordinated Instrumentation on an extensive scale. The illustration shows panel board of system designed for the Gadsden, Alabama, plant of Goodyear Tire & Rubber Company. This Taylor System successfully controlled factors of time, temperature and pressure in curing tires made at this plant and have been in continuous use ever since.

Taylor

Indicating Recording • Controlling

TEMPERATURE, PRESSURE, FLOW *and* LEVEL INSTRUMENTS

Taylor Instrument Companies
95 Ames St., Rochester, N. Y.

Gentlemen: I want to know about Coordinated Instrumentation and what can be done to apply it to my plant and product. Please see that I receive full information.

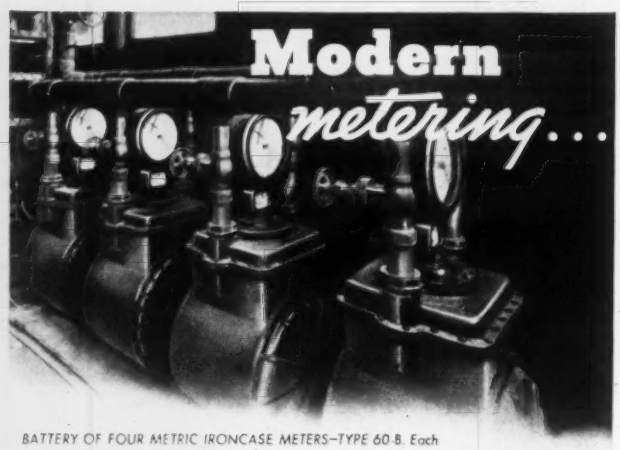
NAME_____

EXECUTIVE POSITION_____

ADDRESS_____

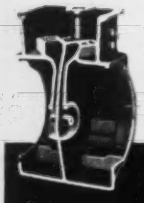
CITY_____ STATE_____

Please attach to your company letterhead



BATTERY OF FOUR METRIC IRONCASE METERS—TYPE 60-B. Each has a capacity of 950 cu. ft. per hour at ½" loss and 2000 cu. ft. at 2" loss, and is equipped with a Westcott Volume and Pressure Gage

METERS SET UP in parallel, facilitate industrial gas measurement and an uninterrupted chart record of the load. Any meter can be cut out of line, for proving or overhauling. Metric Ironcase Meters—sizes 5-B to 500-B—include types to meet all service requirements. The processed one-piece body resists corrosion and eliminates internal leaks. Friction loss is held to a minimum . . . accuracy maintained at highest standard. Descriptive Catalog EG-40 mailed at your request.



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STOCKTON, CALIF.

Fraser Floor Furnaces are compact, gas burning, heating units. Occupy very limited space and produce heat at low cost. Chace Bimetal is the active element used in the safety pilot, which automatically shuts off the gas supply in event pilot is extinguished.

CHACE THERMOSTATIC BIMETAL "It Stands with the Best"

For dependable automatic movement in your product investigate the possibilities of Chace Precision Thermostatic Bimetals. Sold in sheets, in strips and in finished form ready for assembling in your product.

W. M. CHACE CO.
1609 Beard Avenue - - - Detroit Mich.

Instruments
THE MAGAZINE OF MEASUREMENT and CONTROL

VOL. 11 No. 4

APRIL, 1938

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Courtesy The Bristol Co.

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INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

M. F. BEHAR
EDITOR

IN THIS ISSUE

As promised, another article on modern equipment for precision calibration of electrical instruments. The articles in this symposium, you will note, are not repetitious. Last month Egnor described only a few of the devices in the great G-E calibrating department at Schenectady and he did not have occasion to mention that other G-E house of wonders, the standardizing laboratory at West Lynn. This month Gilbert, in four pages, can only tell part of the story of the Weston calibration department. So will it be with future articles: each giving you distinctive ideas as Egnor's did last month and as Gilbert's does this month. The next ones, by the way, may not appear until summer: they aren't ready. As a matter of fact, although Gilbert's was on our desk last fall and definitely scheduled for this issue, it was entirely rewritten since then and his final manuscript (together with the specially-taken photographs and specially-drawn diagrams) only reached us last week!

If these instrument-company physicists and engineers wrote as effortlessly as they invent and develop, we could unhesitatingly announce a rigid future schedule. We hope rather than expect that our coaxing and pleading will bring, for your information, three more precision calibration articles before Christmas.

Professor Williams having discussed penetration-hardness methods in general, he deals this month specifically with the Brinell method and its commercially-available embodiments. Next month, an all American method: the Rockwell.

THE FRONT COVER

shows the gaseous-fuel distribution load-dispatcher's station at the River Rouge plant of the Ford Motor Co. Principal instruments are the receivers of Bristol "Mefameter" systems—fifteen for pressure telemetering and one serving as a receiving tachometer.

NEW AIDS TO CALIBRATION

LAST summer, in the course of a six-week, 10,000 mile vacation, we had the pleasure of going through various manufacturing plants and public utilities. Visits to instrument departments afforded keen pleasure, marred only by regret that in many calibration rooms the precision regulation facilities are still confined to milliwatt levels: no high-precision standards for power-level work!

Back at our desk in September we decided to do two things: (1) Get articles on recently re-equipped calibration laboratories; (2) print a strong editorial on the need of power-level standards. The articles have begun to appear. As for our proposed sermon, we submitted it to famous authorities on instruments and measurements, because it was vehement in spots:

When you plug in to your *regulated* voltage, do you think of it as a "Standard"?

"Oh, but it's different!" you say.

To be sure, a generator weighs several tons and is not an "instrument"; whereas a standard cell is a pocket-size device of exquisite precision. A generator is an active brute; a standard cell a passive jewel. But modern automatic regulators can hold the voltage of a machine constant to $\pm 0.01\%$, the guaranteed precision of standard cells. There should be no discrimination between big and small in calibration work.

Today, few calibration department heads have even thought of having their supplies regulated to $\pm 0.01\%$. Tomorrow, if it becomes common usage to speak of "Standard" supplies, it will also become customary to strive for the best possible regulation of these standards.

The comments by the I&M experts were so much more interesting than our own paltry effort, that we decided to print some and kill our proposed editorial. Here are typical extracts:

FAVORABLE

I like the idea very much indeed. . . . It seems that we accept anything as a standard that can't do anything else than perform as a standard. Otherwise, apparently we don't classify at all: we just accept whatever it is without much thought one way or the other. (M.E.)

Thought-provoking. . . . You can find plenty of "standpatters" who may disagree. . . . The world moves and along with it our ideas as to standards develop. (S.S.G.)

Such regulated voltage supplies *could* be considered as a kind of voltage standard . . . of course, *secondary* standards. (G.M.L.S.)

"OKAY, BUT . . ."

The point that you bring out is a very interesting one. I only differ from you in . . . that I do not know of any regulators that I am confident will hold voltage and speed constant to within 0.01%. (W.B.K.)

Delighted that you have hit on the happy idea of championing the cause of the "forgotten" sources of electrical energy for calibration purposes. . . . There seems to be a constant juggling of the words "source" and "supply." These words have definite meanings. . . . A strong editorial pointing out the advantages, the necessity, and the need for an appreciation of closely-regulated energy sources for calibration work is very much in order. (S.P.S.)

You "have something" and my only criticism is that you do not describe the nature of the devices which will hold within 0.01% a voltage source backed by a substantial quantity of power. (D.A.Y.)

ADVERSE

The regulator, in its efforts to maintain a constant mean value, tends to introduce jerks at most inopportune moments. . . . On straight calibration work I believe hand regulation is still preferable to the uncontrolled performance of automatic regulators. (P.A.B.)

Surprising to me that a regulator can give the performance you describe. (T.S.G.)

In the words of the popular song: "No, No, a Thousand Times No!" . . . The proper term to use would be "regulated supply" and you could add "constant to $\pm 0.1\%$" or "to $\pm 0.01\%$" if you wanted to be so rash. (H.B.S.)

We hold to within $\pm 0.1\%$ at the bus, but would not think of using this standardized voltage without checking it. . . . Our company is striving constantly to improve. . . . I doubt if an editorial will accelerate this work. On the contrary, if the impression were given that such close regulation were obtainable, it would only result in confusion. . . . It would be better if the thoughts which you have written were not expressed. (E.S.L.)

At first I asked myself "So what?" Then I realized that you are pleading for the recognition of the utility of apparatus for producing a constant (not standard) value of supply. . . . Your editorial will confuse the reader. . . . Well, you asked for it! (P.MacG.)

As a view into the future, the editorial gives a good picture. But, at present, the goal is difficult to reach. (C.F.R. and H.R.R.)

NON-COMMITTAL

Awakens various thoughts, some of which are opposed to others. For instance one might say that your "standard supply" is only a standard *pro tem*; the real standard is the standard cell and potentiometer used to check the behavior of the regulator. Against this thought, however, the fact that in time even the standard cell . . . has to be checked against other standards. . . . Even the meter of the archives at Sevres is a bar of alloy and may be suspected . . . Even the angular velocity of the earth is said to be diminishing. . . . (H.B.B.)

Somewhat startling to me, as you probably intended it should be, yet I can find little to "blue pencil." However, why is it necessary or expedient that we call a regulated supply a "standard"? (H.L.T.)

So far as I know, there is no such thing as a standard supply of energy. . . . What I think you had in mind is rather standards of voltage and of current, as this appears throughout your draft; and with this I am in full sympathy. (H.M.T.)

BAILEY METER
CONTROL SYSTEM

The Mark of
Effective Control

Process Control for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

Combustion Control that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.

Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 11.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.

Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

G-3

BAILEY METER COMPANY
1041 Ivanhoe Rd., Cleveland, Ohio

NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

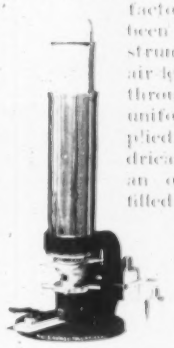
Or write to Information Section, Instruments Publishing Company.

Contact-Making Electrical Instruments

A complete line of contact-making instruments, for use where control or limit indication of electrical circuits is desired without affecting the accuracy of the indicating instrument, includes models with magnetic or non-magnetic contacts. Indicator with magnetic contacts, Model 837, can safely carry 5 watts at 110 volts a.c. Contact adjustment knobs are provided on front of the 6" rectangular case. Each contact is separately adjustable over entire scale, although closest practical setting recommended is 10% of scale between contacts. Manual resetting of the contacts is achieved by means of a push button release on the front of the case. Contact accuracy is within 1%; instrument accuracy 1%. (The two are seldom additive.) This model is recommended for most alarm purposes and other applications where a manual-reset type of instrument can be used. Indicator with non-magnetic contacts, Model 838, differs only in respect to contacts, which require no manual reset; requires a special secondary or auxiliary relay (Model 810), which consists of a sensitive relay, two power relays, a transformer and a rectifier, all housed in a regular 6" rectangular case. Unit will safely carry 5 amps. at 110 volts a.c. non-inductive load. *Weston Electrical Instrument Corp., 583 Frelinghuysen Ave., Newark, N. J.*

Softness-Porosity-Smoothness Tester

New Gurley-Hill S-P-S Tester, for testing printing quality of paper, permits measurement of compression softness, for which it is said that no satisfactory testing method has been available before. Instrument measures a given air-leakage either over or through the paper. Virgil uniform low pressure is supplied by an inverted cylindrical cup floating freely in an outside cylinder partly filled with oil. Graduations on inner cylinder are timed as cylinder displaces air and drops. Tests are made by clamping sample between a fixed upper orifice plate and one of three interchangeable lower plates. *Softness* plate has four steel plugs approx. 0.002" high, pressed into the paper by means of a lever arm and weight, decreasing aperture between plate and paper, so that softer paper is penetrated deeper and gives longer reading. *Smoothness* is measured by clamping several samples, having a hole punched through them, against a lower plate having plane annulus polished optically flat. *Porosity* tests are carried out in same manner as with maker's Improved Densometer. *W. & L. E. Gurley, Troy, N. Y.*



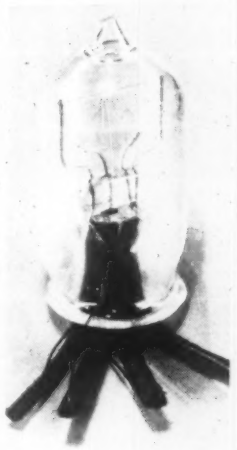
Ultraviolet Source

"Black Ray Projector" is a portable quartz-lamp spotlight with heat resisting filter of specially formulated Wood's glass. Lens is of 6½" equivalent focus. Projector is provided with polished focusing mirror, adjustable lamp receptacle, adjustable bracket and asbestos cord. It uses mercury or Mazda lamps, of which six are available, in wattages from 85 to 500. Mercury lamps require the use of small transformers. These are readily available from the large lamp manufacturing companies. *Black Ray Lighting Co., 5015 St. Clair Ave., Cleveland, Ohio.*

Revolution Counter

A number of important improvements are said to have been made in new model of Belden Revolution Counter, permitting it to operate accurately at "high speed." Direct drive can be furnished to run in either direction. Assembly consists of cast iron base, dust-tight stamped metal case and dial and flexible coupling for connection to driving shaft. "Precision cut gears are used throughout." Large pointer indicates to 100; the other hundreds. Both reset to zero by hand. *The Ideal Commutator Dresser Co., Park Ave., Sycamore, Illinois.*

Vacuum . . . Thermocouples



Ranges from 1 milliampere to 10 amperes, in either contact or separate heater types. Prices from $3.00, quantity discounts.

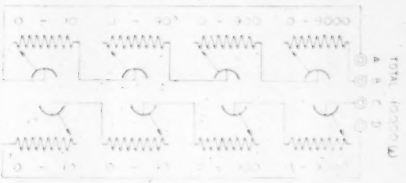
Write for Bulletin "A"

AMERICAN Electrical Sales Co. Inc.

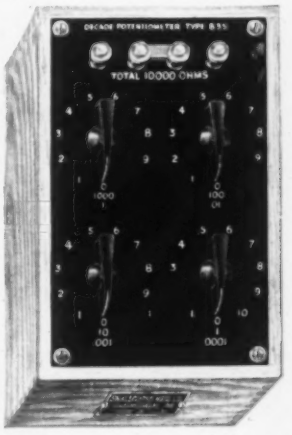
67 E. 8th St. New York, N. Y.

Decade Potentiometer

Designed to provide a precision decade voltage divider having constant internal resistance of 10,000 ohms for all settings of the dials, instrument is actually two 10,000-ohm decade boxes. When switches are rotated clockwise, resistance increases in one set of decades and simultaneously



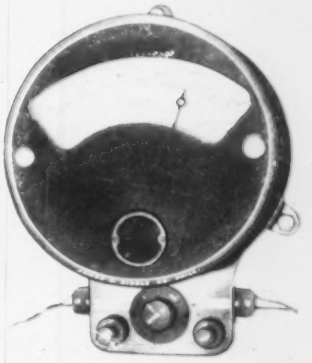
decreases in other set, by same amount, thus at all times total series resistance A-D remains at 10,000 ohms. Either AB or CD may be used independently as a resistance box; when used as a potentiometer, the link supplied is placed across terminals BC. Voltage ratios of



0.0001 to 1.0 may be obtained. Desired settings can be read in steps of 0.0001. When used as a conventional resistance box (AB), the resistance may be varied from 0-10,000 ohms in one-ohm steps. Assembly consists of four Type 532 switches comprising the double decades mounted on Bakelite panel and enclosed in oak case. Resistance units employed are wound non-inductively with manganin wire on non-hygroscopic ceramic forms. Accuracy: resistors in decades other than 1 ohm are held to a tolerance of 0.1%; those of the 1-ohm decade to 0.25%. Dimensions, 9¾" × 6" × 3¾". Net weight, 1¾ lbs. *Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.*

Manual By-pass for Air-operated Control Potentiometer

"Fulscope Micromax Air-operated Potentiometer Controller" (see *Instruments*, Oct. 1937, page 251) now comes provided with a manual by-pass as standard equipment. This permits operator to start on hand control and cut in to automatic. It permits also adjusting instruments without unduly disturbing heat balance in controlled apparatus. *Taylor Instrument Companies, 95 Ames St., Rochester, N. Y.*



"MEGGER"

DIRECT INDICATING OHMMETERS

Because they operate on the "Megger" crossed-coil, true ohmmeter principle, these instruments require no adjustment or "computation" for supply voltage. They measure ohms or megohms as simply as a voltmeter indicates volts. Ranges to as low as .001 ohm and to as high as 5000 megohms. Switchboard and bench types.

Please write for descriptive Bulletin 1501.

JAMES G. BIDDLE CO.

ELECTRICAL INSTRUMENTS

1211-13 Arch Street Philadelphia, Pa.

S-M-O-O-T-H VOLTAGE CONTROL for A.C. circuits

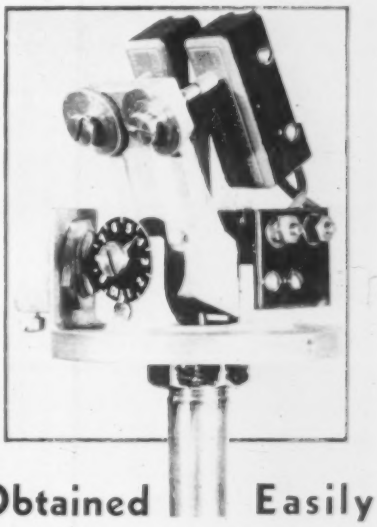
The Type "TH" Transtat is the new continuously variable auto-transformer regulator . . . the ideal voltage control for a.c. circuits. It offers high efficiency, good regulation, great flexibility and dependable construction at moderate cost. Standard types are available for controlling voltage to single-phase and polyphase loads rated 10 Kva. and smaller, 50 or 60 cycles, 115, 230 or 460 volts. May we send you bulletin 51-1 which contains complete data?

TRANSTAT VOLTAGE REGULATORS

AMERICAN TRANSFORMER CO.

178 Emmet St. Newark, N. J.

A MULTITUDE of CIRCUITS



Obtained Easily

With new two-switch model Burling Temperature Control. Ideal for variable-load applications and for equipment where extremely close control is desired.

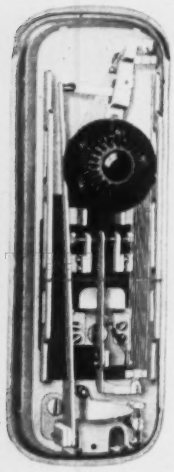
Send for particulars

BURLING INSTRUMENT COMPANY

239-241 Springfield Ave. Newark, N. J.

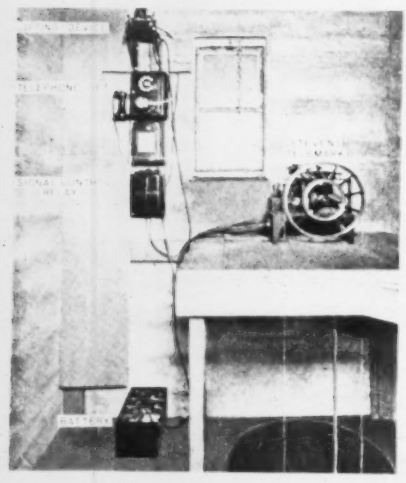
Redesigned Comfortrol

Neither temperature alone, nor humidity, but a combination of the two, results in a given body-sensitive condition, termed "effective temperature." See *Instruments*, Sept. 1930, pages 560-563 for underlying principles; May 1934, page 101, for technical description of original "Comfortrol." Redesigned model is of same size and outside appearance as maker's standard thermostat, combines thermal and hygroscopic elements, is suitable for application to any type of heating equipment (oil, gas, stoker, etc.) or to any type of cooling equipment. By means of Friez Summer-Winter Switch, a single instrument can be used for controlling heating equipment in winter and cooling equipment in summer. *Julien P. Friez & Sons, Baltimore, Md.*



The "Telemark"

Stevens Telemark is a radically new type of telephone circuit telemetering device, consisting only of a transmitter which "answers" (lifts receiver) and "speaks" (emits coded audible signals) when its regularly assigned number is called up from any telephone capable of connection to the telephone set with which it is associated. Signals do not interfere with telephone communications. Any type of telephone service is suitable: private or commercial systems, the transoceanic radio system, or any combination. Obvious applications are gasometer position, valve position, river stage or other liquid level indication, etc, at locations so remote that use of existing telephone service is necessitated. Transmitting station comprises (in addition to standard telephone set and signal control relay) a receiver-lifting device, a storage battery and the Telemark itself. The latter comprises a positioning element connected to the float, valve, gasometer, etc., and a signaling element. Positioning element comprises three disks, each divided into ten sectors, each sector containing a different number of ridges, so that any reading from "000" to "999" can be transmitted. Inherent accuracy of this is 0.1% when full range is utilized. Signaling element starts operating when the telephone number of the installed set is called; ringing current actuates telephone company's signal control relay, closing battery circuit, energizing two motors. One motor lifts telephone receiver and stops; the other rotates a contact arm sweeping over sectors of disks which have been positioned by the valve or float. Simultaneously, an electron-tube oscillator is energized to produce, whenever contact arm rides over a ridge, a musical tone emitted into telephone mouthpiece by an ordinary earphone receiver held by soft-copper tubing. After three sets of signals (total duration approx. 45 sec.) telephone receiver hook is lowered and transmitter automatically resets itself for the next call. Signals are interpreted by counting short tones (digits) and writing zero when hearing a long tone. *Leupold, Volpel & Co., 425 N.E. 20th Ave., Portland, Ore.*



• FINE WIRE
• RIBBON and
• FOIL . . . . .

OF

"CLOSER-THAN-COMMERCIAL" TOLERANCES

★

Obtainable in

Pt, Au, Ag, Ni, Cu, Fe, Al, or any special alloys

★

BARE WIRES drawn to .0006" diameter

RIBBON rolled to less than .0001" thick

FOIL rolled to less than .0005" thick

★

GALVANOMETER SUSPENSION STRIP

CLOSE SCIENTIFIC CONTROL OF CHEMICAL COMPOSITION AND PHYSICAL CHARACTERISTICS. High purity; exact size, weight and elongation; high tensile strength; accurate torsional properties, resistance and temperature co-efficient of resistance.

★

Specialists in Precise Control of specifications for difficult alloys for:

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- GALVANOMETER SUSPENSIONS
- RESISTANCE and FUSE WIRES

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a companion piece to the Applied Research projection comparator (see *Instruments*, March 1938, page 82), is constructed for use therewith, consists of two units containing phototube, amplifier and microammeter. "Photocell" unit comprises a phototube and a vacuum-tube amplifier mounted together in a cast aluminum housing having a slit 0.3 mm. wide, backed with a condensing lens. This unit is mounted behind the projection comparator screen with the slit in the face of the screen so that a line projected on it falls on the phototube. "Meter unit" contains microammeter, batteries and voltage compensator, allows direct measurement of transmission of a spectral line to within 1%. Operation of instrument requires no special training. Two knobs allow zero and sensitivity to be readily adjusted. Line to be measured is brought near slit on screen by means of course adjustment, then slowly passed over slit with a vernier adjustment knob. Transmission values of six lines can be read in one minute. *Applied Research Laboratories, 1208 San Julian St., Los Angeles, Calif.*

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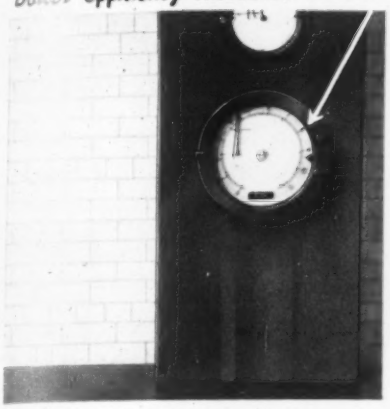

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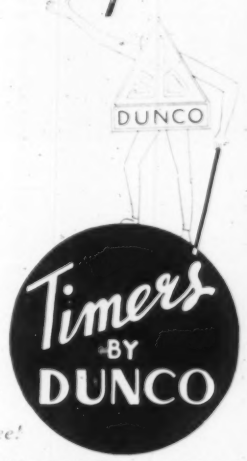

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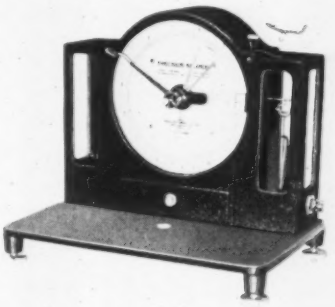
Chief purpose of Sequence Furnace Draft Control is to prevent blow-back occurring at the ignition period in the on-and-off type of oil and gas burners an dstokers. Device is electrically operated, opens up-take damper wide an instant before burner or stoker comes on. Thus ignition is accomplished without "explosion." Damper is then closed to position required for good combustion, after which the regular draft control operates. Other purposes: (1) To prevent too high a draft during "off" period of stoker-fired boiler—even though it may be near normal during "on" period. (2) Some types of oil and gas burners do not shut off air during "off" period, so that when burner is not operating, boiler functions as a radiator. New device eliminates both types of losses by regulating combustion chamber draft to a low and efficient value during the "off" as well as the "on" periods of stoker or burner operation. *The Hays Corp., P. O. Box 299, Michigan City, Indiana.*

Assay Balance

This is a fast, direct-reading balance with a total range of 0.10 mg., accuracy of 0.005 mg. and zero temperature error. General construction is similar to that



of the maker's Model B Precision Balance. Assay Balance has knife edges instead of pivots, springs with zero temperature error and beam of new design and construction. Guaranteed accuracy is 0.1% of full scale. A prism, available as an extra, bends pointer image 45° and permits reading the zero pointer without shifting head to eliminate parallax errors. *Roller-Smith Co., 233 Woolworth Bldg., New York City.*

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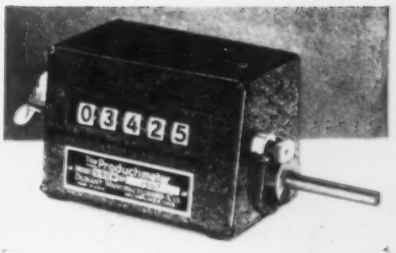
Developed to enable a single photograph taken straight down from an airplane to show an area three times greater than heretofore possible from same altitude, "Metrogon" lens covers 90° of field, yet has negligible edge aberration. These properties, plus focal length 5¼", f:6.3 and center-sharpness of definition limited only by graininess of emulsion, make a combination regarded as an optical achievement, opening up new applications in other fields than aerial mapping. *Bausch & Lomb Optical Co., 635 St. Paul St., Rochester, N. Y.*



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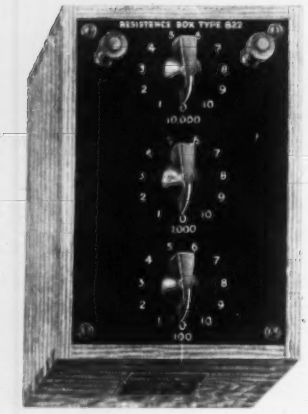
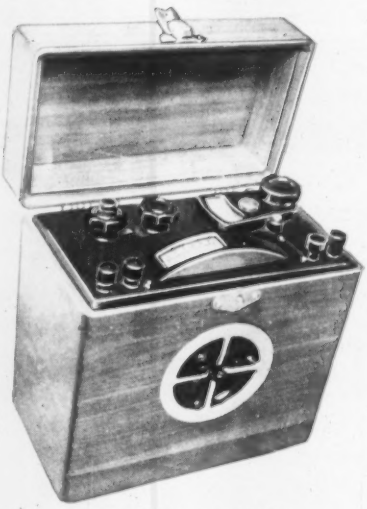
Guaranteed accuracy of 0.1% characterizes new series of decade boxes having a total resistance of 11,111,100 ohms in six decades to 110 ohms in three decades. "800 Series" decade boxes are suitable for a.c. measurements up to 1000 cycles. Due to type of winding of individual resistors, impedance approximates d.c. resistance. Resultant reactance is said



to be negligible in a.f. range up to 20 kc. Boxes are suitable for use as resistance standards for percentage bridge, in electronic tube circuits, as voltmeter multipliers, etc. They are regularly furnished in 3, 4, 5 and 6 decade models. "Type 531" switches are enclosed and contacts are protected from dust and corrosion. Multi-leaf phosphor bronze contact arm, however, maintains constant wiping action on contact studs. Units are calibrated at 72° F. and will change approx. 0.1% for every 10° above or below 72° F. *Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.*

Automatic Still

Stadler Automatic Still, entirely made of acid and alkali resistant Jena G 20 glass, is so designed that water in the distilling vessel is held at constant level by automatic additions of warm water. Condenser and distilling flask are so balanced that any change in water content of flask disturbs equilibrium and tilts the still, diverting into flask the required amount of warm water from overflow of condenser. When balance is restored, waste water from condenser flows to drain until more is required. Since flask receives only enough warm water to replace distillate, still is said to be more efficient than usual laboratory water stills. Its efficiency can be further increased by a heat insulating jacket. Capacity depends upon the burner and gas used but is normally 2 to 2.5 liters per hour. Nothing but highly resistant Jena G 20 glass comes in contact with the distillate. Residue can be cleaned from distilling flask when necessary and reagents for purifying water can be introduced, without taking the still apart. An interchangeable ground-glass joint between flask and condenser facilitates taking apart. *Fish-Schurman Corp., 250 E. 23rd St., New York City.*



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Timers set the Standard for Enduring Dependability

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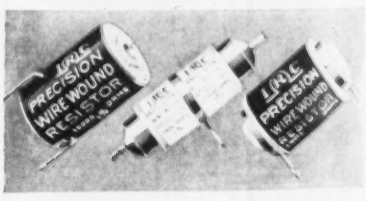
Reflex-Vickers Hardness Testing Machine

Designed for rapid hardness tests on "very thin or very hard" metal sections by Vickers diamond pyramid indentation method. When load is applied, by turning hand crank (upper right) diamond

indenter is switched into its position over test surface; when load is released, by turning same crank backwards, indenter is moved away and a microscope objective swung into position over indentation. Magnified (70× or 140×) image of indentation then appears on ground-glass screen. This Reflex arrangement serves also to position specimen correctly before load is applied; if entire image is in focus, diamond pyramid will penetrate at right angle and indentation will be "perfectly square." In addition to Vickers diamond, Brinell balls (0.625, 1.25 and 2.5 mm.) are available as indenters. *Herman A. Holz, 167 East 72nd St., New York City.*

Precision Resistors

Eight new units bring total of IRC Precision Wire Wound Resistor types to twelve, giving a complete range of inductive and non-inductive units. New Types WW-5, WW-6, WW-7, WW-8



and WW-9 represent intermediate sizes for flexible mounting. Various types of terminals are supplied on all. In new Types WW-12, WW-13 and WW-14, feature is that resistance wire is returned to the lead internally through the ceramic and yet completely insulated and protected from windings or mounting bolts. All units are wound on ceramic cores with Nichrome or copper nickel wire. Special impregnation is employed to protect the windings. *International Resistance Co., 417 N. Broad St., Philadelphia, Pa.*

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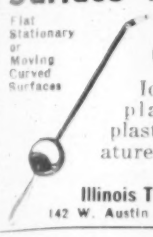

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Ideal for rolls, molds, plates, platens and plastic material temperatures.

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ALNOR Electronic Type
PYROMETER CONTROLLER

For all industrial applications

Ranges 0-600 to 0-3000

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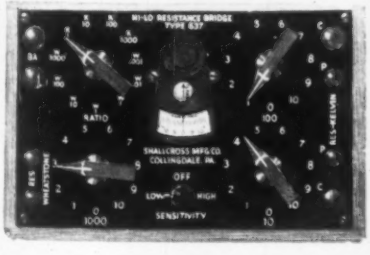
The New
TWO-IN-ONE SHALLCROSS
HI-LO RESISTANCE BRIDGE

A convenient compact little instrument, completely self contained for measuring any resistance from .00001 ohm to 11.1 megohms.



Specially practicable for measuring the resistance of relay contacts, coils, armature windings, etc.

This one unit includes both a standard Kelvin Bridge and a standard Wheatstone Bridge.

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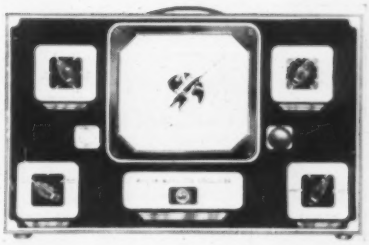


Test Oscillator

Circuit of Model 776 Test Oscillator provides automatic amplitude control at any required level from 1 to 100,000 μv. Unit is designed for high-stability operation from any 110-120 volt, 60-cycle, a-c line, with output characteristics independent of fluctuations in line voltage. Direct-reading 330° dial, with six frequency scales averaging over a foot in length, is individually calibrated with hand-drawn scale divisions, obviating all use of trimmer condensers. Six wave bands:

50-200 kc.	1.8-6.0 Mc.
200-600 kc.	6.0-18 Mc.
500-1800 kc.	18-30 Mc.

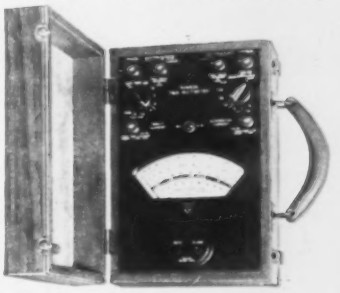
Further stability is assured by a new type of band switching unit: six coils mounted directly on switch—no wire connections or leads. Accuracy guarantee 0.5% on three i-f. and Bc. wave bands; 1% on the three short-wave bands. Output voltage constancy at all frequency settings is achieved by a circuit which automatically changes mutual conductance of oscillator tube in proportion to signal fed to attenuator. Scale is graduated in even divisions from 1 to 100 with a 4-position multiplier switch for direct, ×10, ×100 and ×1000 settings; direct-reading in microvolts output. In order that no energy reach receiver except at the terminals, shielding is unusually complete, even the line cord being shielded right to the plug. Wave form is permanently held. Provision is made for r-f. output modulated at 400 cycles, for continuous wave output, (CW) and for a-f. oscillation. A wobbler jack permits frequency modulated input to unit. Four tubes are utilized in the circuit: a rectifier, the oscillator and amplitude control tube, a buffer and a modulator. Despite its wide range coverage in frequency and output level, Model 776 is easily portable. *Weston Electrical Instrument Corp., 581 Frelinghuysen Ave., Newark, N. J.*

Universal Motors

For various industrial measurement and control applications, "HL Series" fractional h.p. motors with reduction-gear units are announced in two types: totally enclosed housing and 30-min. rating; and ventilated housing and continuous rating. Double gear-shaft extension makes possible either direction of rotation. Numerous models available: 1/92-1/38 h.p., 83-929 r.p.m.

The Dunmore Co., Racine, Wis.

Rawson Twin Multimeter



29 ranges in less space than any near equivalent combination—size 12" x 8" x 6"

RANGE OF MEASUREMENTS

D.C.—1 microampere to 1 ampere
20 microvolts to 1000 volts
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2 milliamperes to 5 amperes
60 millivolts to 1000 volts

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The Rawson measuring instruments are the only ones having two pivot movements whose weight is lifted from jewels when clamped for transit. Electrical clamping does not accomplish this purpose.

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An accurate record of the specific gravity of gas.

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THE REFINERY SUPPLY CO.
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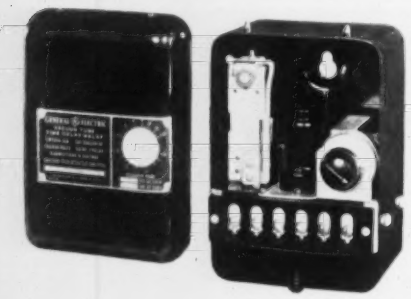
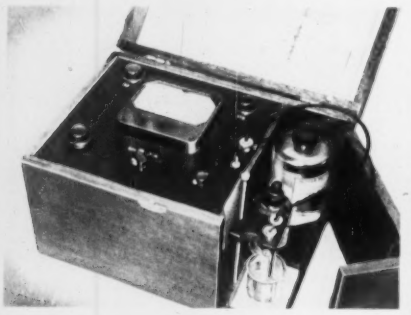
General purpose timer is applicable to industrial machinery, particularly machine tools, which require a definite time delay during operation. Electronic portion of new device consists of a G E 6C5



three-element, high-vacuum metal tube which is said to give long life to the timer and can be replaced through any radio supply store. Timer is arranged to operate on either 115 or 230 volts, 50 or 60 cycles. Contact tips are rated 1 amp. at 115 volts and 0.5 amp. at 230 volts. Calibrated scale has 10 divisions proportional to time; maximum and minimum operating times on 115 volts are approx. 60 sec. and 3 sec. Resetting time is about 5 sec. for 100% timing. Timing is reduced to 90% for a resetting time of about one second. *General Electric Co., Schenectady, N. Y.*

Industrial pH Meter

New model of Beckman pH Meter is said to combine extreme accuracy of glass electrode system with operating simplicity and over-all ruggedness; can



be used by non-technical men; is said to have several exclusive features including: (1) Glass electrode system sufficiently rugged to be safely used in viscous or semi-solid substances and in rapidly circulating or flowing liquids. (2) Electrode system and lead wire shielded for remote installation without picking up electrostatic interferences. (3) Continuous pH indication when button is locked down, leaving operator's hands free for titration, etc. (4) Dual scale instrument and changeover switch: in first position full scale covers acid range, 0-7 pH; in second position full scale covers alkaline range, 7-14 pH. Readings can be made to 0.02 pH. Outfit is entirely self-contained in hardwood case with detachable safety cover that cannot be closed until meter is completely shut off. *National Technical Laboratories, 3537 E. Colorado Blvd., Pasadena, Calif.*

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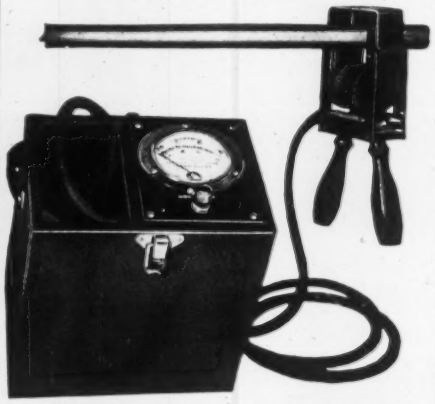
Without opening circuit to insert an ammeter you can measure alternating current by using a RUBICON



SPLIT CORE TEST SET

Highly useful in checking motors and other devices for load, performance and phase balance without interfering with operation. Simple, accurate and inexpensive. Ranges to 1000 amps.

Send for Bulletin No. 180

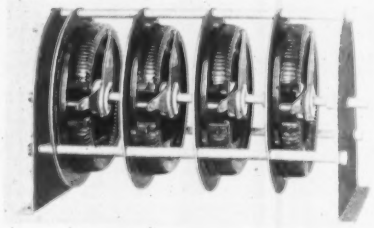
RUBICON COMPANY

Electrical Instrument Makers

29 North Sixth St. Philadelphia, Pa.

Rheostat Assemblies

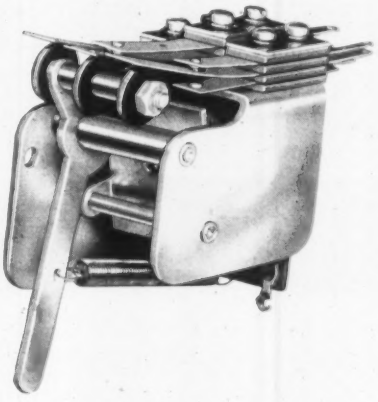
Embodying maker's larger-size rheostats, this new type of gang assembly is used for the control of electrical apparatus where several circuits are to be simultaneously varied, as in the control of the individual phases of a 3-phase line, etc. Assembly illustrated consists of four



"Model U" rheostats rated at 1,000 watts each, overall length approx. 38" and height 15½"; is intended for motor drive, is equipped with separate bearings on end plates. Each rheostat is individually driven from the ¾" shaft through a special "Ohmite" universal coupling designed to eliminate lost motion. New construction and assembly can be supplied for 2, 3, 4 or more rheostats in co-axial relation, using any combination of 300-, 500- or 1,000-watt units. *Ohmite Manufacturing Co., 4835 Flournoy St., Chicago, Ill.*

Circuit-breaker Relay

New "Type B" relay with magnetic release is usable as an overload cut-out, a manual-reset annunciator drop, with an off-level indicator, in conjunction with



a pendulum bob. It is intended for low-voltage service, up to 24 volts. Three contact stack mounting positions permit three operating switches at a single level. Where necessary, additional contact combinations can be added to any one of the three stacks. It can be used in multiple assemblies with a common reset arm. *G M Laboratories, 1731 Belmont Ave., Chicago, Ill.*

SPEED RECORDERS

also non-graphic tachometers with "running-time" register. The reliable **T&L** chronometers made by Hasler & Berne Switzerland. Ask for new bulletin.

R. W. Cramer & Co. 67 Irving Place, New York N

Practical Standardization of POWER SOURCES for Instrument Calibration

By R. W. GILBERT

Development Engineer, Weston Electrical Instrument Corp., Newark, N. J.

INTRODUCTION

REGULATION of voltage and current sources for calibration of electrical instruments has long been a problem in standardizing laboratories, and a particularly acute problem where a great deal of routine calibration is involved. When the operator is confronted by occasional fluctuations requiring readjustment of the calibrating potentiometers, the probability of human error is greatly increased even when the extent of these variations is not intolerable.

In the case of direct current magnitudes the most stable power source available in the past has been the lead acid storage battery. However, where a number of calibrating tables are operated from a common battery and are being turned on and off at random, stability of the supply voltage becomes dependent upon the resistance of the battery and common supply line—an unsatisfactory condition at best with new batteries, and aggravated as the battery ages and its internal resistance rises.

The standardizing and calibrating laboratories of the Weston Electrical Instrument Corp. were recently confronted by this aggravated situation: the aging of heavy storage battery banks that had been in use for many years. The prospect of replacing several thousand dollars' worth of storage batteries without achieving a permanent solution prompted investigation of the possibilities of substituting a regulated motor-generator set. Several types of regulators were tried and it was found possible to equal the steady state voltage regulation of a heavy bank of new batteries. However, control was obtained by varying the field of the generator; the high field inductance caused a lag that prohibited its use; and sudden changes of load caused temporary voltage changes of sufficient duration to cause bad deflections of the calibrating potentiometers and instruments being calibrated.

The limitations of the generator-regulator method advanced the necessity for obtaining regulation independent of generator characteristics, requiring direct control, probably by some electronic method. At this time it occurred to the laboratory personnel that it might be possible to go a step further and obtain a standardized power source instead of simply a regulated source. Furthermore, such a source could ultimately be made to provide standardized magnitudes for direct calibration of instruments rather than simply a stable source of voltage for operation of conventional calibrating potentiometers.

A practical basic method was worked out; the units to be described were built, and produced excellent results. Because it is necessary not to interfere with regular production facilities, installation of standardizing regulators is necessarily slow and the present units were recognized at the start as not the ultimate but were placed in service to prove the basic method and to meet an emergency. Results, however, have definitely indicated their worth and more extensive application of the method is contemplated.

METHOD BASED ON STANDARD CELL AND STANDARD RESISTOR

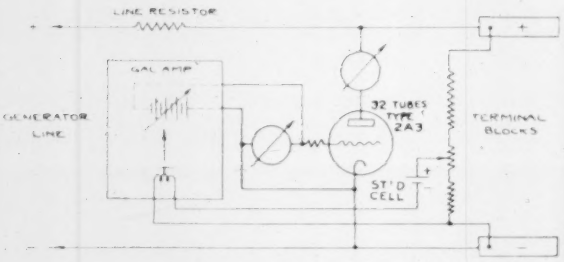
It is well recognized that the most reliable practical reference standard is the emf. of a standard cell and the resistance of a precise resistor. Both are capable of a stability within a few parts per million over long periods of time under service conditions. The standard cell and resistance were thus adopted as the working standard for the regulator. Basically, a current through the standard resistor provides a voltage drop that must be maintained in balance against the standard cell voltage, requiring a null detector. For this purpose the permanent magnet - moving coil galvanometer is unsurpassed, and offers a practical method of detecting potentiometric unbalance. It is now necessary, first, to establish a potentiometer divider (or a shunt) to balance the magnitude being regulated against the standard cell; second, to provide a means for controlling the magnitude in response to galvanometer deflections in order to maintain potentiometric balance. Another stipulation is that this balancing action be sufficiently rapid to rebalance instantaneous variations before they are noticeable on the instruments being calibrated.

In the Weston Photoelectric Potentiometer an instrument was available peculiarly adapted to this purpose and containing a null galvanometer sufficiently sensitive for the precision required. This instrument has been described elsewhere[1] so only its characteristics pertinent to this application will be treated here. Briefly, it consists of a self-contained power pack, and a mirror galvanometer and optical system operating in conjunction with an electronic circuit to produce an output in response to galvanometer deflections. Ordinarily this device is used as a measuring instrument and as such contains standardized potentiometer resistors. However, as used in the regulators to be described, the potentiometer resistors, if any, are external to the unit—which is then no longer a self contained potentiometer but simply a "galvanometer amplifier"—and shall be referred to as such. The optical and electronic systems are so arranged that a galvanometer deflection in the order of 10 minutes of angle will produce an output voltage in the order of 30 volts. This output can then be applied to some device, usually a bank of vacuum tubes, capable of exerting a continuous control over the magnitude being regulated. Thus a ready method is available for adjusting the magnitude continuously in response to potentiometric unbalance, to maintain a standard value.

The galvanometer used is a double pivoted type having

[1] Instruments, Dec. 1935, page 343; also manufacturer's technical description, Circular B501.

no spring restoring force. The absence of spring torque enables it to respond to currents merely sufficient to overcome initial pivot friction or unbalance components, resulting in a sensitivity high in comparison to the usual indicating instrument. In general the manufacturing tolerance for these components in terms of moving coil power is 5×10^{-10} watt. Assuming a standard cell resistance of 200 ohms (which is high) the galvanometer



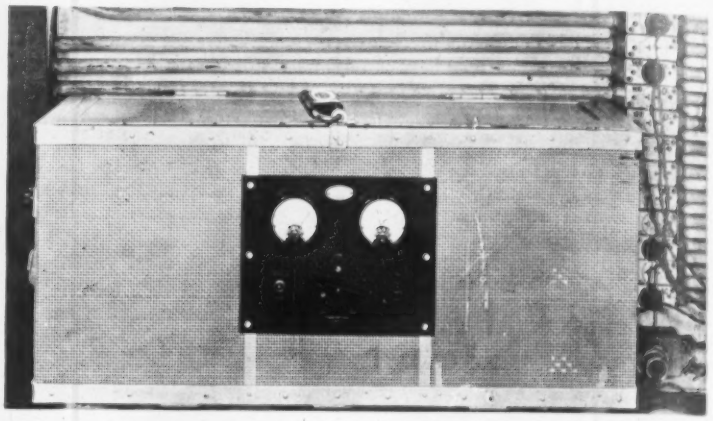


Fig. 1. D-c. Voltage Regulator: Simplified diagram; and photograph of the regulator as installed on calibrating line.

resistance for a proper match would be 200 ohms (neglecting the additional circuit resistance which can be made negligible). This energy demand at 200 ohms represents a current demand of 5×10^{-3} ampere, or a voltage demand in the 400 ohm circuit of 2×10^{-1} volt. Against a nominal standard cell voltage of 1 volt this represents a sensitivity of 1 part in 50,000. Allowing for additive variations in standard cell voltage and resistance values, and some loss of galvanometer sensitivity with time, practical results better than 1 part in 10,000, or 0.01%, are reasonably assured. As 0.01% is a useful order of precision for the great bulk of calibrating demands, this figure was accepted as the overall tolerance on the standardizing regulators designed for standardization of direct currents or voltages.

The speed of regulation of such a system, assuming that the response of the controlled magnitude to galvanometer deflections is instantaneous, is a function of the amount of inertia of the galvanometer, and the "tightness" of the system; that is, the increment of galvanometer current produced by an increment of deflection away from the balance position acting through the system. As galvanometer deflections produce a proportional current through its windings, an action is set up analogous to the action of spring restoring force; the device as a whole has a natural period similar to that of a conventional indicating instrument, and the speed of regulation is best expressed in terms of this period. However, in this case an extremely small deflection will cause a relatively large restoring torque due to current, much larger than that due to the springs in indicating instruments, resulting in periods much shorter than usual. In practice no difficulty was encountered in obtaining periods of 0.07 second, and periods as short as 0.03 second were obtained experimentally.

By the foregoing method a basic system is available for the production of true standardized voltages or currents at useful "power load" wattages. Adaptation to practice now simply involves use of the proper associated circuits and devices, selection of which is determined by the characteristics desired: load range, stability of power source (generator or line), values of voltage or current desired, etc.

The first installation was designed to operate as a simple regulator to replace the old storage battery supply, rather than primarily as a standardized source. The immediate advantage was that it could supply the laboratory calibrating tables without necessitating any change in calibrating procedure. A 170-volt generator was installed in the old battery room to supply the regulator which was located in the calibrating laboratory. The voltage was standardized at 152.50 volts between two heavy copper terminal bars; and each calibrating table had a private line to the terminals to avoid common line drop. The terminal blocks simply provided a voltage source of perfect regulation within functional limits. The regulator was designed to accommodate loads up to 3 amperes at the regulated voltage.

The circuit diagram in Fig. 1 shows this unit as installed. The galvanometer amplifier unit is shown schematically for simplicity. It merely supplies a grid voltage to a vacuum tube bank in response to galvanometer deflections. A bank of 32 parallel Type 2A3 tubes is shown in the diagram as one tube for simplicity. The d-c. line resistor provides the necessary drop in voltage to obtain control by virtue of the total plate current of the tube bank. The tube bank must be capable of drawing current at least equal to the total range of load current, 3 amperes, as it controls the voltage by drawing the portion of current not demanded by the load. The Type 2A3 tube was selected because it offered the best combination of high current capacity (120 milliamperes per tube), low plate resistance, and low cost. A plate ammeter and grid voltmeter are provided primarily to indicate the condition of the tubes in the bank. It has been found that all tubes have a fairly parallel life; presumably any tube deteriorating faster than the others automatically receives less of the load and will last as long as a tube having an initially longer life. It was found necessary to equip each tube of the bank with an individual grid resistor to suppress a peculiar type of high-frequency intertube oscillation that sometimes occurs when tubes of this type are closely paralleled.

The potentiometer circuit is a simple voltage divider containing a multipoint switch in one section as an adjustment to the certified voltage of the particular standard cell used. The resistance values were adjusted in position between the terminal bars to avoid lead resistance errors.

The next logical step in the program of providing standardized power sources for instrument calibration was to develop a device, operating from an unregulated source, which would be capable of providing any desired standardized value of voltage or current for instrument

...ication directly. Such a device should be capable of ...ding as many ranges of voltage and current as pos... each range being divisible in a sufficient number of ...ps to calibrate all the cardinal points on the instru... scale. It should provide these standardized values ...hout correction for load factors such as resistance in ... case of current instruments, and current demand or ...sitivity in the case of voltmeters.

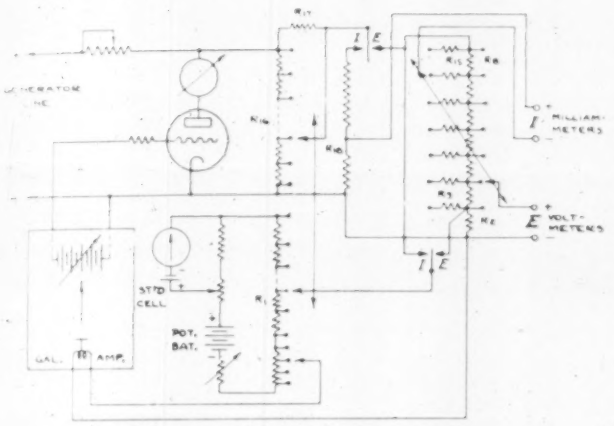


Fig. 2. Schematic Diagram of the Calibrating Regulator.

An experimental instrument was built having seven ranges of voltage and seven ranges of current: 1.5, 3, 7.5, 15; 30, 75, and 150 volts and milliamperes, each range divisible in 15 steps and subdivisible in 10 steps. The circuit diagram of this regulator is shown in Fig. 2. It was found impractical to operate from the standard cell directly, so standard potentiometer practice was employed by using a standardized current supplied by a battery. This current passes through a dividing resistor R_1 which is tapped for the 15 coarse and 10 fine steps, the drop across the taps being balanced against the shunt and voltage divider. For the sake of simplicity the same set of resistors R_2–R_5 is used both as a shunt for currents

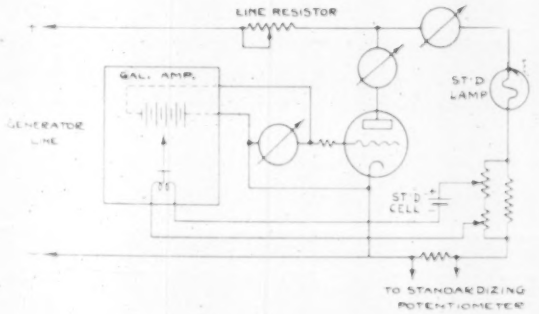


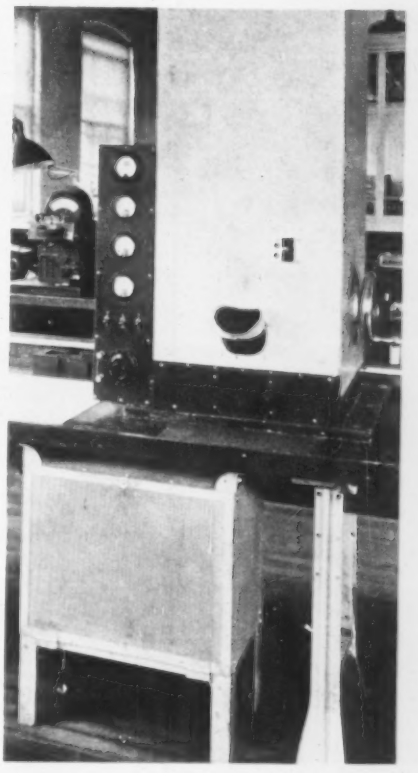
Fig. 3. Current Regulator for Photometer: Simplified diagram; and photograph of installation.

and as a potentiometer divider for voltages, the necessary switching being done by the voltage current changeover switch. Insofar as the ranges are symmetrical both voltage and current ranges are read on the same switch dial, the taps for each corresponding range of current and voltage being taken starting from opposite ends of the resistance. For example the 1.5 volt range calls for the lowest point on the divider, while the 1.5 milliampere range calls for the highest point or the greatest resistance as a shunt, and conversely for the 150 volt and milliampere point. For simplicity the diagram illustrates this condition by arrows indicating the direction of switch rotation when going from lower to higher ranges.

In order to operate the tube bank near the midpoint of its current range for all demands of current or voltage, it is necessary to provide a constant load resistance network operating in conjunction with the coarse divider switch. This is conveniently done by the tapped shunt and series resistors R_{14} and R_{15}, having 15 taps operating with the coarse divider switch. This network alone is satisfactory for voltage ranges, but for current ranges it is necessary in addition to provide a suitable series resistance component on each range to maintain proper voltage leads. This is done by first dividing the overall voltage to a low value (20 volts) by means of R_{13}, and then introducing a proper amount of series resistance in each step on the current side of the range resistor, R_6–R_{12}. The foregoing networks, when properly adjusted, cause the system to balance against all demands of voltage or current with the tube bank plate current at a median value and ready to go up or down to balance against changing supply line voltage or various instrument demands. The regulator is capable of accommodating voltmeters having sensitivities of 60 ohms per volt or higher, and all milliammeters including the relatively high resistance thermal types.

PHOTOMETRIC STANDARDIZATION

The same basic method of automatic standardization has been applied to the regulation of current through the standard lamps used for the calibrating of Photronic light measuring instruments. As the light output of an incandescent lamp varies as almost the fourth power of



the lamp current, accurate light standardization requires precise control of lamp current. The photograph, Fig. 3, shows a vertical photometer equipped with a standardizing regulator as shown in the diagram. As the lamp current setting is only changed when lamps are changed or restandardized, the regulator does not include a calibrated adjustment of lamp current but simply contains a standard shunt for connection to a portable potentiometer for adjustment to the standard value. The uncali-

brated adjustment, consisting of coarse and fine adjustments, is used to obtain a potential drop from the current circuit for balance against the standard cell. Once the current is standardized, the setting is reliable if undisturbed, and the current value is entirely independent of normal amounts of resistance change such as the lamp socket contact resistance.

A-C. VOLTAGE STANDARDIZATION

A somewhat similar system is in use in the Weston laboratory for regulation of a-c. voltage. In a-c. work, unfortunately, the standard cell cannot be used as a

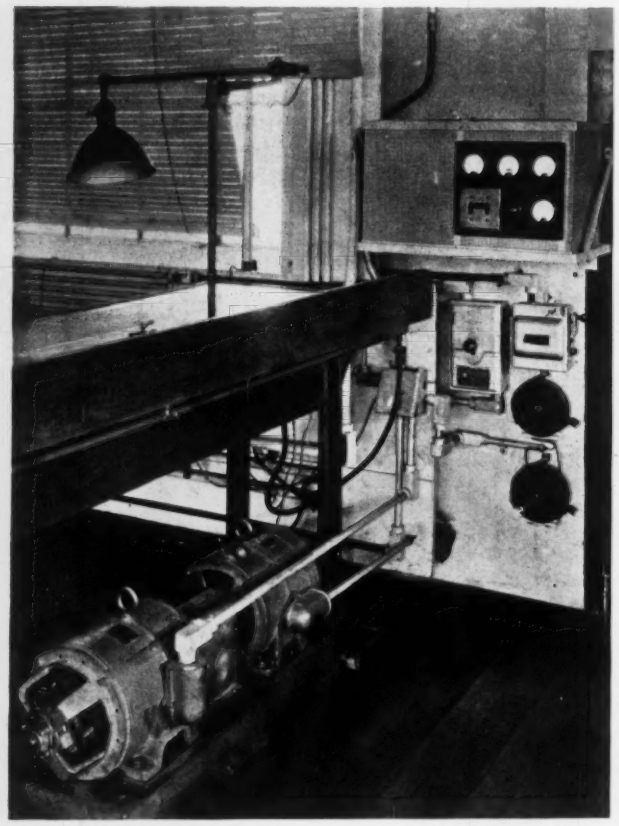


Fig. 4. Regulator for A-c. Voltage Source.

reference, so simple regulation only—not true "standardization"—is possible. Furthermore, as a relatively pure wave form is all-important for instrument calibration, a special generator must be used and cannot be loaded with non-linear devices such as the tube bank used for d-c. regulation. This necessitates control by varying the field excitation and introduces the objectionable lag of the field inductance. Although far from perfect because of these conditions, the system is still a considerable improvement over the unregulated generator and at least provides an a-c. source of good steady-state regulation.

A number of methods were tried for interpreting the r.m.s. voltage into d-c. terms for operation of the galvanometer. Non-linear bridges of both the saturating-reactor and resistive types were tried but for various reasons were not satisfactory. The thermocouple-heater combination proved highly stable but was far too sluggish for the purpose. The method finally adopted (Fig. 4) comprises an incandescent lamp illuminating a Photronic cell from the generator output. The cell output current is bucked against an adjustable battery current and the differential used to operate the galvanometer. The galvanometer amplifier in turn controls the grids of the usual tube bank carrying a portion of the generator field current.

After a ten-minute run to allow the cell fatigue effect to become negligible, the system shows a regulation of better than 0.1 percent. Instantaneously-applied loads cause a momentary change noticeable in instruments being calibrated, but the voltage is pulled back within 0.1 percent in about one second.

FREQUENCY STANDARDIZATION

Calibration of tachometers and frequency meters requires a readily adjustable source of standardized rotational speed, or its complement, frequency. A system similar to the foregoing methods is in use in the Weston laboratory, utilizing a specially-designed tachometer generator operating against a standard potentiometer as a reference standard. As the tachometer generator is fundamentally linear, standardization at one frequency will apply closely to all frequencies by simple interpolation

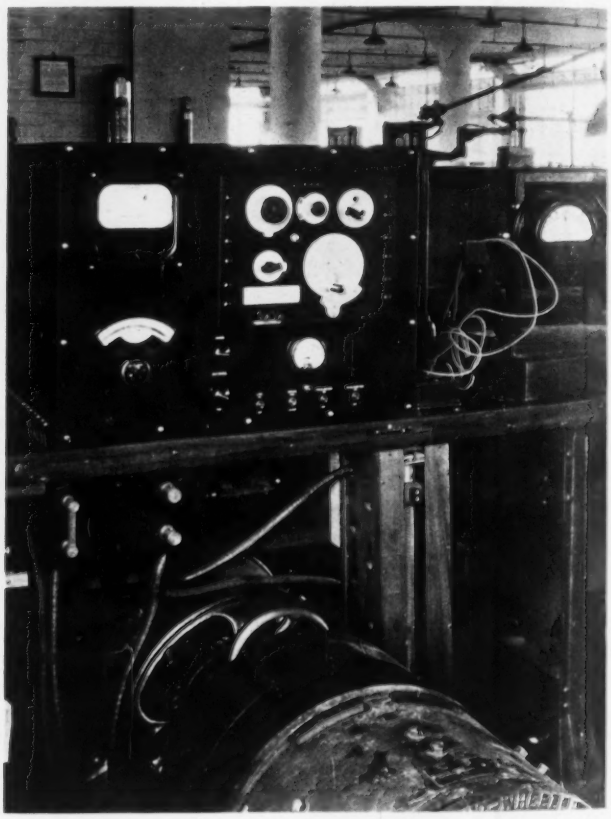


Fig. 5. Frequency Standardizing Regulator.

on the potentiometer. As the tachometer generator is in a null circuit, the temperature coefficient of its copper windings has no effect.

This device arranged as a standard frequency source is shown in Fig. 5. An alternator is driven by a d-c. motor having purposely poor speed regulation, the speed being controlled by the action of a magnetic brake on the shaft of the motor. The brake current is supplied through a tube bank which in turn is operated by the galvanometer amplifier. The set-up is periodically standardized by stroboscopic comparison against a 60-cycle tuning fork.

The Brinell Hardness Testing Method

By S. R. WILLIAMS
Professor of Physics, Amherst College

BRINELL'S HARDNESS TESTER

"The name Brinell[1] will always be associated with the subject of hardness. "In the year 1900, J. A. Brinell, who was then Chief Engineer at Fagersta Iron Works in Sweden, presented a paper to the Swedish Society of Technologists (Swenska Teknologföreningen), in which he gave the results of hardness determinations of materials according to his new method.."

"The Brinell Ball Test Method consists of the forcing of a hardened steel ball, under a definite pressure, into the specimen. The dimensions of the impression thus obtained form the basis for calculating the hardness. By dividing the pressure in kilograms by the spherical surface of the impression, expressed in square millimeters, the 'Brinell Hardness Number' is obtained:

$$H = \frac{P}{\frac{\pi D}{2}\left(D - \sqrt{D^2 - d^2}\right)}$$

H being the Brinell Hardness Number, P the load in kilograms, D the diameter of the ball and d that of the impression in millimeters. Fig. 93 shows a form of the Brinell instrument for general purposes.

"The method of using is very simple. After measuring the diameter of the ball impression by means of a microscope especially designed for the purpose [see Fig. 94] the corresponding number is obtained from Table I. The machine consists of a vertical hydraulic press, into the cylinder of which oil is forced by means of a hand pump *a*, Fig. 93. On the lower part of the piston is a ball holder (*b*) to which the ball, to be pressed into the specimen, is fixed. The specimen is placed on press table *d*, vertically adjustable by means of handwheel *c*. The press table rests in the cup-shaped top of the screw, and may be inclined in any direction so that the plane surface of irregular specimens may be adjusted to a horizontal position.

"The ram works without packing, as the friction caused by such an expedient would impair the accuracy

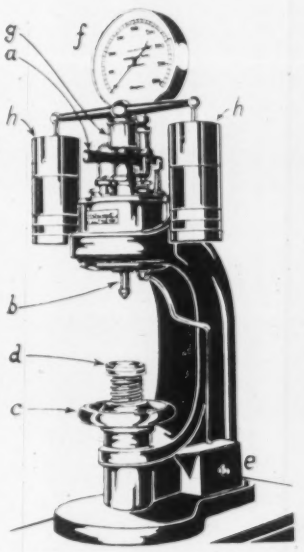


Fig. 93. The Brinell Hardness Testing Machine. "Original" Type made by Aktiebolaget Alpha, Stockholm, Sweden.

Fig. 94. Illuminated type Brinell Microscope, with direct-reading counter. (Pittsburgh Instrument & Machine Co.)

[1] J. A. Brinell & Gunnar Dillner, Die Brinell'sche Harteprobe und ihre praktische Verwendung, International Association of Testing Materials Brüsseler Kongress, 1906, *Report on Problem 27E*; pages 1-27.
A. Wahlberg: Brinell's Method of Determining Hardness, *Journal Iron and Steel Institute*, Vol. 59, Vol. 1 of 1901, pages 243-298.
[2] Quotations taken from literature issued by manufacturer: Aktiebolaget Alpha, Stockholm, Sweden. U. S. agent, H. A. Holz, 167 East 33rd St., New York City.

TABLE I—BRINELL HARDNESS NUMBERS—10 mm. Steel Ball

Diameter of Ball Impression (Mm.)	Hardness Number for a Load of (Kg.) 500	3000	Diameter of Ball Impression (Mm.)	Hardness Number for a Load of (Kg.) 500	3000	Diameter of Ball Impression (Mm.)	Hardness Number for a Load of (Kg.) 500	3000	Diameter of Ball Impression (Mm.)	Hardness Number for a Load of (Kg.) 500	3000	Diameter of Ball Impression (Mm.)	Hardness Number for a Load of (Kg.) 500	3000
2.00	158	945	3.00	69.1	415	4.00	38.1	229	5.00	23.8	143	6.00	15.9	95.5
2.05	150	899	3.05	66.8	401	4.05	37.1	223	5.05	23.3	140	6.05	15.6	93.7
2.10	143	856	3.10	64.6	388	4.10	36.2	217	5.10	22.8	137	6.10	15.3	92.0
2.15	136	817	3.15	62.5	375	4.15	35.3	212	5.15	22.3	134	6.15	15.1	90.3
2.20	130	780	3.20	60.5	363	4.20	34.4	207	5.20	21.8	131	6.20	14.8	88.7
2.25	124	745	3.25	58.6	352	4.25	33.6	201	5.25	21.4	128	6.25	14.5	87.1
2.30	119	712	3.30	56.8	341	4.30	32.8	197	5.30	20.9	126	6.30	14.2	85.5
2.35	114	682	3.35	55.1	331	4.35	32.0	192	5.35	20.5	123	6.35	14.0	84.0
2.40	109	653	3.40	53.4	321	4.40	31.2	187	5.40	20.1	121	6.40	13.7	82.5
2.45	104	627	3.45	51.8	311	4.45	30.5	183	5.45	19.7	118	6.45	13.5	81.0
2.50	100	601	3.50	50.3	302	4.50	29.8	179	5.50	19.3	116	6.50	13.3	79.6
2.55	96.3	578	3.55	48.9	293	4.55	29.1	174	5.55	18.9	114	6.55	13.0	78.2
2.60	92.6	555	3.60	47.5	285	4.60	28.4	170	5.60	18.6	111	6.60	12.8	76.8
2.65	89.0	534	3.65	46.1	277	4.65	27.8	167	5.65	18.2	109	6.65	12.6	75.4
2.70	85.7	514	3.70	44.9	269	4.70	27.1	163	5.70	17.8	107	6.70	12.4	74.1
2.75	82.6	495	3.75	43.6	262	4.75	26.5	159	5.75	17.5	105	6.75	12.1	72.8
2.80	79.6	477	3.80	42.4	255	4.80	25.9	156	5.80	17.2	103	6.80	11.9	71.6
2.85	76.8	461	3.85	41.3	248	4.85	25.4	152	5.85	16.8	101	6.85	11.7	70.4
2.90	74.1	444	3.90	40.2	241	4.90	24.8	149	5.90	16.5	99.2	6.90	11.5	69.2
2.95	71.5	429	3.95	39.1	235	4.95	24.3	146	5.95	16.2	97.3	6.95	11.3	68.0

of the machine. Leakage is prevented by the accurate fitting of the ram into the press cylinder, which is such as to keep the moving and stationary surfaces sufficiently close together, without actual contact. The small quantity of oil which does pass the piston collects in vessel *e* and is returned periodically to the press cylinder through the funnel.

"The pressure exerted by the piston is recorded on a gage graduated in kilograms, but as one can never rely on a gage keeping permanently accurate, the machine is provided with a controlling device which accurately regulates the pressure to that required for the test. This controlling device consists of a small cylinder *g* in direct communication with the main cylinder. The piston in the

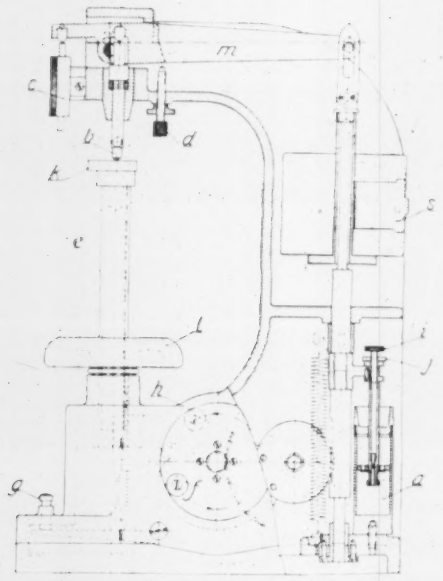


Fig. 95. Vertical section of the Alpha Durometer. (Herman A. Holz.)

small cylinder is loaded with weights *h* corresponding to the testing load required. When the weights rise, the requisite pressure is attained. This pressure cannot be exceeded, and keeps constant as long as the weights are floating. The pressure is released by opening the release valve. Thus the attained pressure keeps constant for the time required for the test. Incorrect readings are completely excluded. When the indications on the gage differ from those of the hydraulic control, the gage is always at fault."

Weights corresponding to pressures of 250, 500, 750, 1000, 1500, 2000, 2500, and 3000 kg. are supplied with each machine. It is recommended that:

"For Brinell Ball Tests on iron and steel a ball of 10 mm. diameter and a load of 3000 kg., or a ball of 5 mm. diameter and a load of 750 kg., should be used. For copper alloys: 10 mm. ball with a load of 1000 kg., or 5 mm. ball with a load of 250 kg. For copper: 10-mm. ball with 500 kg. load. (See Brit. Stand. Tables of Brinell Hardness Numbers, No. 240, 1926.)"

When testing hard steel objects, (*H* exceeding 525-550) it may occur that ordinary steel balls are not sufficiently hard for producing distinct indentation. In such cases (up to *H* = 675-700) the "Hultgren's Extra hard Steel Balls" may be used.

As pointed out by Dr. Brinell, in his first paper, the ultimate tensile stress *T* of wrought or rolled iron or steel can also be determined when the hardness number *H* is known, but only for these materials.

Sir Robert A. Hadfield has found that

$$T = 0.313H \text{ (10 kg. mm.}^{-2}\text{)}$$

$$= .445H \text{ (1000 lbs. in.}^{-2}\text{)}$$

$$\text{approximately } 0.2H \text{ (6 tons in.}^{-2}\text{)}.$$

Fig. 26* shows this relation graphically.

Brinell's method rests on the principle that the number as a measure of hardness is given by the equation:

$$H = \frac{\text{Applied Load}}{\text{Contact Area of recovered indentation}}$$

There are other indentation methods which employ variations of this equation.

Certain precautions are to be observed in the use of Brinell and other types of indenter hardness testing machines. The samples should not be so thin as to have the bottom layers of the substance disturbed by the indenter applied to the top surface. Also the indenter should not be applied so near to the edge of the material that a flow of the metal will occur in that direction.

THE ALPHA DUROMETER

This is an instrument designed especially for hardness tests of small tools, tubing, hardened steel parts and sections which do not readily lend themselves to a standard Brinell test. Because of greater rapidity in making tests

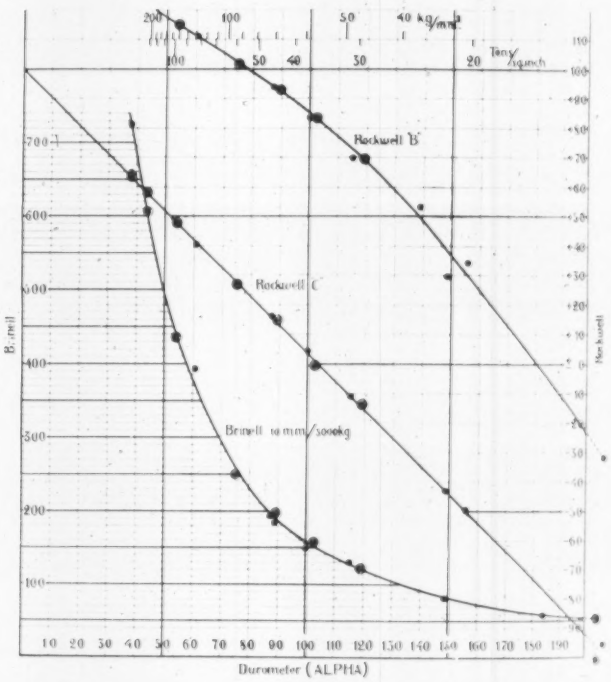


Fig. 96. Relations between the hardness numbers as given by various hardness testing machines. The scales at the top of the diagram indicate approximately the ultimate tensile stress for rolled and wrought iron and steel when the Brinell-hardness, Alpha-hardness or Rockwell-hardness is known.

this instrument uses the depth (rather than the diameter) of the indentation as a measure of hardness. It is to be said, however, that the loss of time in reading the diameter of the impression can be avoided by reading the depth on the dial gage corresponding to the diameter of the impressions for the respective hardness numbers. In

*April 1937 article.

3W. C. Unwin. The Ludwik Hardness Test. *Proceedings Institution Mechanical Engineers*, Oct.-Dec. 1918, pages 485-597.

...nd the relation between depth and diameter of ...pression should be established for each kind of mate... in different stages of hardness and plotted on a ...ph or recorded in a table. In this way rapid routine ...ts in mass production may be made according to the ...Brinell method.

Fig. 95 shows a vertical section of the Alpha Durome... Inasmuch as this form of the Brinell machine is quite similar to the Rockwell which is to be described later, the Alpha Durometer may be used in making comparative measures on the Brinell, Durometer, Rockwell C and Rockwell B scales. Fig. 96 is a diagram showing the approximate relations between the different hardness scales as well as the ultimate tensile strength for rolled and wrought iron and steel when the various scale hardnesses are known. If one wishes to make tests according to the Rockwell C scale, a diamond cone, accurately ground to an angle of 120° and with a rounded point, is used as an indenter. In the Durometer test the indenter is a diamond cone accurately ground to an angle of 120° but with a sharp point. This form is used because the manufacturer believes that he can duplicate such a cone more accurately than the one with the rounded point. When it is desired to carry on hardness tests according to the Brinell or Rockwell method, balls of various sizes and with different loads are used as indenters. In testing the hardness of a substance with a diamond cone indenter, the cone is forced into the object to be tested under an initial load of 10 kg. and a final load of 150 kg.

Fig. 97. Olsen Brinell Hardness Tester.

The increase of the depth of the impression due to the increment of load of 140 kg. is taken as an indication of the hardness. After the full load has been applied and the conditions have become static, the extra 140 kg. is removed and the depth of the impression is measured.

One complete revolution of the longer pointer is equivalent to a movement of 1 millimeter of the spindle of the dial indicator and each division to a movement of 0.01 mm. of the spindle. Inasmuch as the penetration of the diamond cone is amplified to give a movement five times as great on the indicator scale, each scale division of the dial corresponds to a depth of impression of 0.002 mm. One complete rotation of the long hand indicates a depth change of 0.2 mm. The possibility of carrying out Durometer and Rockwell diamond cone tests as well as Brinell and Rockwell ball hardness tests, makes this instrument more universal than many others.

OTHER BRINELL MACHINES

The manufacturers of the original Brinell machine in Sweden make other and larger machines. Some are so built as to be mounted on columns straddling a narrow gage track on a concrete bed in order that the specimens can pass through the machine on a carriage.

Quite a number of other manufacturers in Europe and, of course, in America, have produced so-called Brinell Hardness Testers. Fig. 97 shows a form put out by the Tinius Olsen Testing Machine Co. of Philadelphia, Pa. It is a rugged substantial machine, built for testing in quantity production and is of the motor-driven, hydraulic

Fig. 98. The Olsen Baby Brinell, for testing soft metals and non-metallic materials.

type. This machine may be controlled by a foot pedal, although hand control is preferable as it gives more uniform results under quantity production. The standard maximum load of 3000 kg. is smoothly and accurately applied. There are twelve weights for applying various loads by increments of 250 kg. up to 3000 kg. Olsen machines are equipped with the standard Brinell 10 mm. ball. Unfortunately, Americans persist in making steel balls measured in English units.

For testing the hardness of soft metals and materials, the Olsen Baby Brinell shown in Fig. 98 operates on the Brinell principle but with light weights and small balls. The load is applied directly from dead weights to the ball indenter, giving sensitiveness and yet reliability under the small load used. A 1/16" ball is used with a load of 12.61 kg. as this load bears the same relation to the 1/16" ball that the 500 kg. load does to the 10-mm. ball in the Standard Brinell Test. However, comparative Brinell Hardness readings cannot be secured by this relation and hardness numbers in the use of this equipment should be used only as determined by a special table of numbers furnished with the machine.

In Fig. 99 will be found a recent development of the Brinell Testing Machine as put out by the Steel City Testing Laboratory of Detroit, Michigan. It is a hand

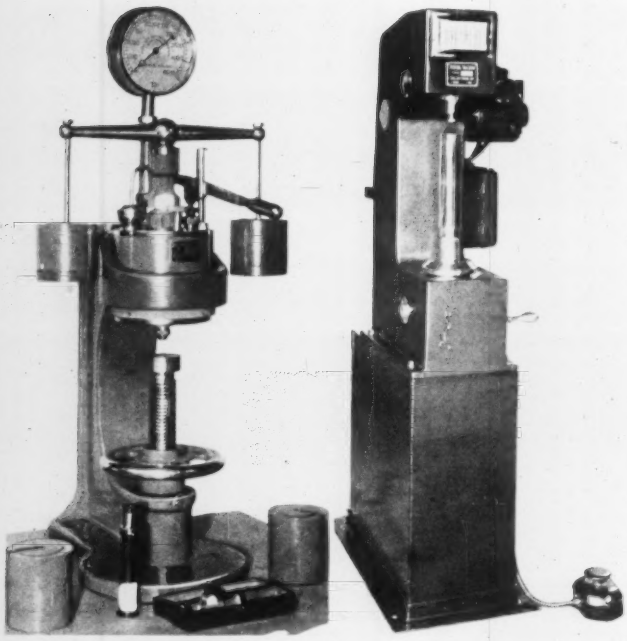


Fig. 99. Fig. 100.
Special Brinell machines made by Steel City Testing Laboratory.

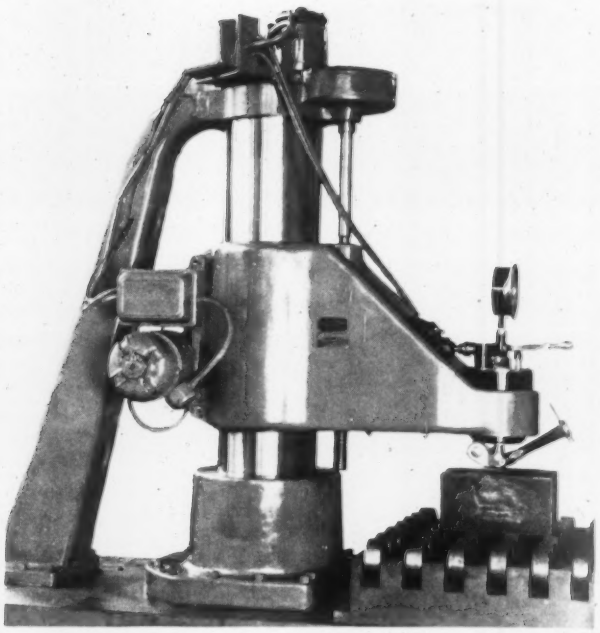


Fig. 101. Special Brinell machine with provision for conveying large and heavy parts, made by Pittsburgh Instrument & Machine Co.

operated machine in which the procedure for measuring hardness is the regular Brinell method. In their literature the manufacturers state that "For practical purposes, the tensile strength can be assumed to be one-third of the hardness number in metric units; or the hardness numbers can be multiplied by the coefficient 0.346 as a uniform constant and the result obtained will be the ultimate tensile strength of the material." In Fig. 100 is shown a power-operated Brinell machine made by the same company.

Among the many forms of Brinell machines, developed for production line testing in industry, is the one shown in Fig. 101 and made by the Pittsburgh Instrument & Machine Co. The articles to be tested move along a continuous conveyor track until they arrive at the base of the hardness tester where they meet a multiple roller arrangement whereby the specimens roll under the indenter and then pass on again to the continuous conveyor track on the other side of the base of the hardness tester.

In describing the original Durometer above, reference was made to the time-saving advantage of reading depth on an indicator instead of measuring diameter through a microscope. Many machines are made, employing this method, which are primarily designed for utmost time saving. Fig. 102 shows one (3000-kg. load and 10-mm. steel ball) made by the Gogan Machine Corp. of Cleveland, Ohio. From this company's literature we quote the following: ". . . Nothing to do but to insert piece to be tested, press foot pedal and read hardness number."

Fig. 102. Rapid hardness tester made by Gogan Machine Corp.

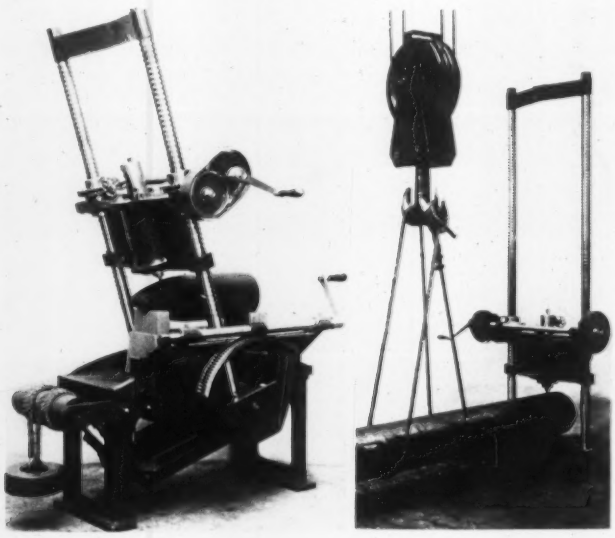


Fig. 103. Fig. 104.
Special Brinell machines made by Alfred Amsler.

Alfred J. Amsler[1] gets out an extensive line of hardness testing machines, both hand- and motor-driven. Figs. 103 and 104 show two of this firm's large machines for heavy, cumbrous specimens. In the U. S. A. the test loads have been definitely standardized at 3000 kg. for ferrous metals and alloys, and at 500 kg. for non-ferrous alloys. 5000-kg. loads such as some Amsler machines use would not be standard in the U. S. A.

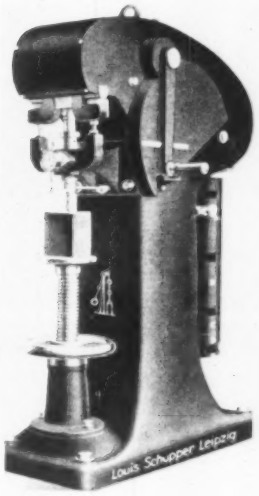


Fig. 105. Hardness tester, for Brinell and other tests, made by Louis Schopper.

Louis Schopper[2] carries another extensive line of hardness testers, ranging all the way from light, portable testers up to those employing heavy loads. Fig 105 shows one of this type. A feature is "a hydraulically operated regulating device, by means of which the *rate* of the load application may be set to suit requirements."

Apart from structural features, there is little difference between the various so-called Brinell machines as put out by the leading manufacturers. All use the same basic method: indentation. This applies not only to American machines but also to English and continual European products. One could go on showing instruments of one make and of others indefinitely.

DYNAMIC INDENTATION

The foregoing machines depend upon a static load to give the indentation of the ball or the diamond point. For some time there has been a call for a machine which will measure hardness in terms of dynamic loads because in so much of our machinery it is just that type of load against which the machinery must resist. The Olsen company has brought out the Ballentine Hardness Testing Machine[3] of the dynamic indentation type shown in Fig. 106. In the first place the indentation is made by a blow and, therefore, being instantaneous, it can be operated more rapidly than the static type and the manufacturers claim as great an accuracy for the machine as for the static type. This machine gives a hardness scale of definite physical units in which the energy absorbed in making an indentation is compared with the volume of the indentation. The units are inch-pounds of absorbed energy compared to volume of indentation in thousandths of a cubic inch. The resulting scale is one in which each hardness unit has the same meaning as every other unit.

[1] Schaffhausen, Switzerland. U. S. agent, H. A. Holz, 167 East 33rd St., New York City.

[2] Leipzig, Germany. U. S. agent, Testing Machines, Inc., 400 West 34th St., New York City.

[3] W. M. Patterson, A New Method and Machine for Dynamic Hardness Testing, *Proceedings A.S.T.M.*, Vol. 35, Part 2, 1935, pages 305-317; discussion, pages 316-322.

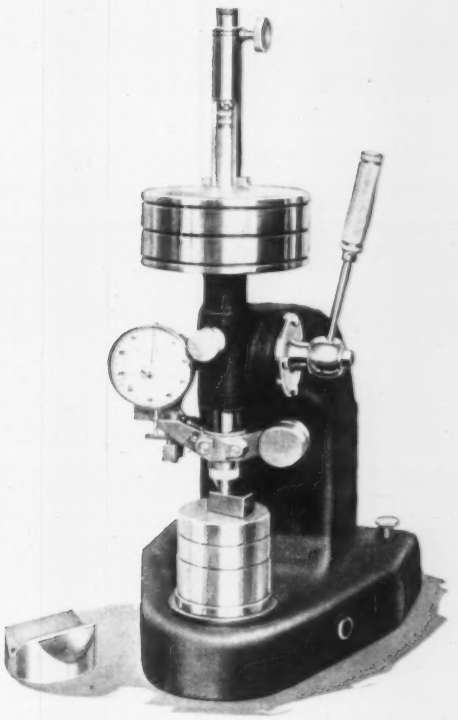


Fig. 106. The Ballentine Hardness Tester, a fast dynamic indentation tester. (Tinius Olsen Testing Machine Co.)

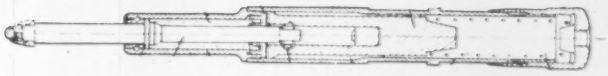


Fig. 107. Steel City Testing Laboratory's hardness-testing hammer.

Although it belongs primarily in a later article, on Portable Hardness Testers, the hardness-testing hammer made by the Steel City Testing Laboratory may be mentioned here, because it employs a dynamic indentation method. Fig. 107 shows this simple device—an adaptation of the regulated-tension spring hammer, striking uniform blows.

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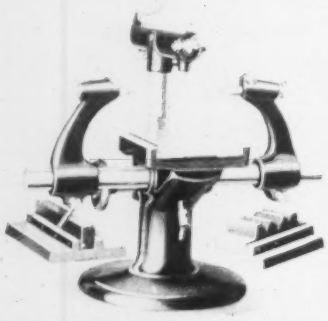

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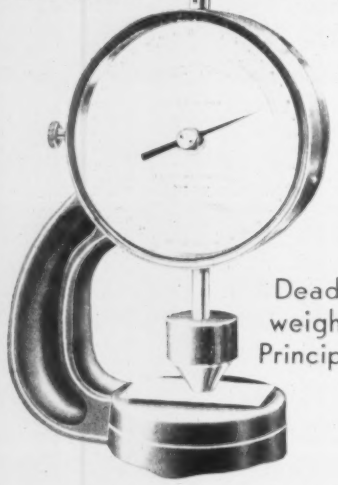

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INSTRUMENTATION FORUM

PROBLEMS — SOLUTIONS — DISCUSSIONS

FEBRUARY PROBLEM (No. 16)

CONTINUOUSLY MEASURING SMALL FLOW OF LIQUID

Research Director seeks method of indicating flow rate of methanol: 0.3 to 5.0 lbs./hr.; has found drop-count methods inaccurate.

85 PRIZE SOLUTIONS

WILLIAM H. DeWITT
ROCHESTER, N. Y.

KERMIT K. FISCHER
PHILADELPHIA, PA.

both of whom independently reported that the commercially-available float-type variable-area constant-head flow-indicating devices known as Rotameters are made up in models sufficiently tiny to indicate a flow rate of 0.3 lb./hr. with sufficient accuracy.

both of whom gave evidence of understanding that this flow-rate corresponds to that of a slowly dripping faucet: about one drop per second.

both of whom suggested two Rotameters in series, one with a *minimum* readable capacity <1 cc./min., the other with a *maximum* calibrated capacity >60 cc./min., to take care of the relatively large flow variation, given as 16.6 to 1, and with scale to spare at both extremes.

It is lucky for *Instruments* that only two subscribers sent in this "complete" and "perfect" solution of Problem No. 16. If all readers acquainted with the products of Schuette & Koerting Co. and of Fischer & Porter Co. (the two manufacturers of Rotameters) had entered their two-Rotameters-in-series solutions before March 15, *Instruments* might have had to award several hundred five-dollar prizes. As a matter of fact, one other subscriber, Robert H. Mixson, Hampton, Va., suggested this variable-orifice type, but he definitely asserted that the range of one Rotameter would be adequate so we award him an Honorable Mention but no cash prize.

Altogether, ten solutions and discussions were sent in. We mailed them all to the Research Director whose inquiry we had printed as Problem No. 16. To our astonishment, his comments did not qualify any solution as "complete." He explained that his original inquiry had been too brief: His real problem is to feed the methanol at a rate determined by the flow of another fluid. This, of course, is nothing less than a problem in automatic flow-ratio control or "proportioning control" one of the most difficult phases of industrial instrumentation. For our part, we had to judge the entries with regard to "Problem No. 16" the problem which we printed, which only implied that the flow-rate of the methanol has to be constant in order that indications can be read accurately, and which said nothing about automatic proportioning. To us, the two-Rotameter solution entered independently by DeWitt and by Fischer is complete; and it is "perfect" because it only involves commercially-available parts nothing to contrive, construct, calibrate and cuss-at for days or weeks until it works.

Several entrants, in their discussions, remarked that Problem No. 16 did not give the desired accuracy; and they submitted schemes which unless embodied in apparatus of superlative workmanship, costing hundreds of dollars for

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Problem No. 18 Subject Index 5

SPECIAL TIME BASE FOR CATHODE-RAY TUBE

"In connection with an application of the cathode-ray tube, I require a time base that will move the spot horizontally across the screen every one-fifth of a second, or multiple thereof, beginning always at the same edge. This transit across the screen need not be at uniform velocity from edge to edge, but all successive transits must be absolutely identical in duration. Duration should not exceed one-hundredth of a second. The beam must begin its sweep every fifth of a second (or multiple) without being off more than two or three millionths of a second."

EDITOR'S NOTES—(1) Presumably, duration to be adjustable UP TO 0.01 sec. and inquirer will frequently use a setting of a millisecond or less, for it is only at such speeds that a timing variation of 2 or 3 microseconds would matter. (2) Presumably, return trace to be suppressed.

Five dollars will be paid for every solution (or critical discussion clearly pointing to way to a solution) which is accepted for publication. Address Instrumentation Forum, 1121 Wolfendale St., Pittsburgh, Pa. Type double-space, on one side of paper. Draw diagram in black ink on separate sheet. Diagram must not be larger than 5" x 5" and must stand reduction to 2⅛" wide. (His neatness will count, in this particular case.) Mail before May 15. Solutions and discussions accepted will appear in June 1938 issue.

alone would probably show errors ... at low flow. These entrants ... to appreciate that the words ... count methods inaccurate" have ... only a qualitative but a quantitative ... We did not print "± 0.5 ac... required" because the Research ... chose to cite the drop-count ... ison; and also because we could ... know just how uniform the metha... drops are under the conditions of ... process temperature, impurities and ... conditions which may vary and ... variations in surface tension. How... we felt certain that interested read... would know that *in general* the ac... of the drop-count method (assum... constant temperature, etc.) depends ... on the ratio of the counting period ... the drop rate: even the lowest flow (0.3 lb. hr.) could be measured to ± 0.12% over a two-minute period; and the average flow (2.65 lbs. hr.) could be measured to ± 0.41% over a one-minute period. A simple, relatively inexpensive photoelectric drop-counter and electric timer was described in *Instruments*, July 1935, pages 170-173, by H. Hunter Smith, who reported in effect that all drops of a given fluid issuing from a given capillary orifice are exactly alike in weight.

$5 PRIZE SOLUTION

By JOHN M. MEYER
SAN FRANCISCO, CALIF.

No space for more than a brief abstract of this entrant's manuscript, or for his drawing of a rather elaborate apparatus. He proposed that the methanol, at room temperature and 10-lb. gage pressure, be dripped (at a fairly constant rate; unimportant) onto the bottom plate of a heated chamber; and that the stream of *vapor*, maintained at 180° F., flow through an orifice meter and then through a condenser.

"What makes you think [we wrote him] that your orifice would be more sensitive than one metering *exactly the same mass-rate* of liquid methanol?"

He replied in effect that he didn't, but that (1) trouble with clogging of tiny parts would be obviated and (2) size of orifice for vapor would assure square-root law and permit better calibration of manometer.

Commented the Research Director: "By far the best original solution of all ten . . . Am afraid that the necessary controls would rule it out as far as our application is concerned."

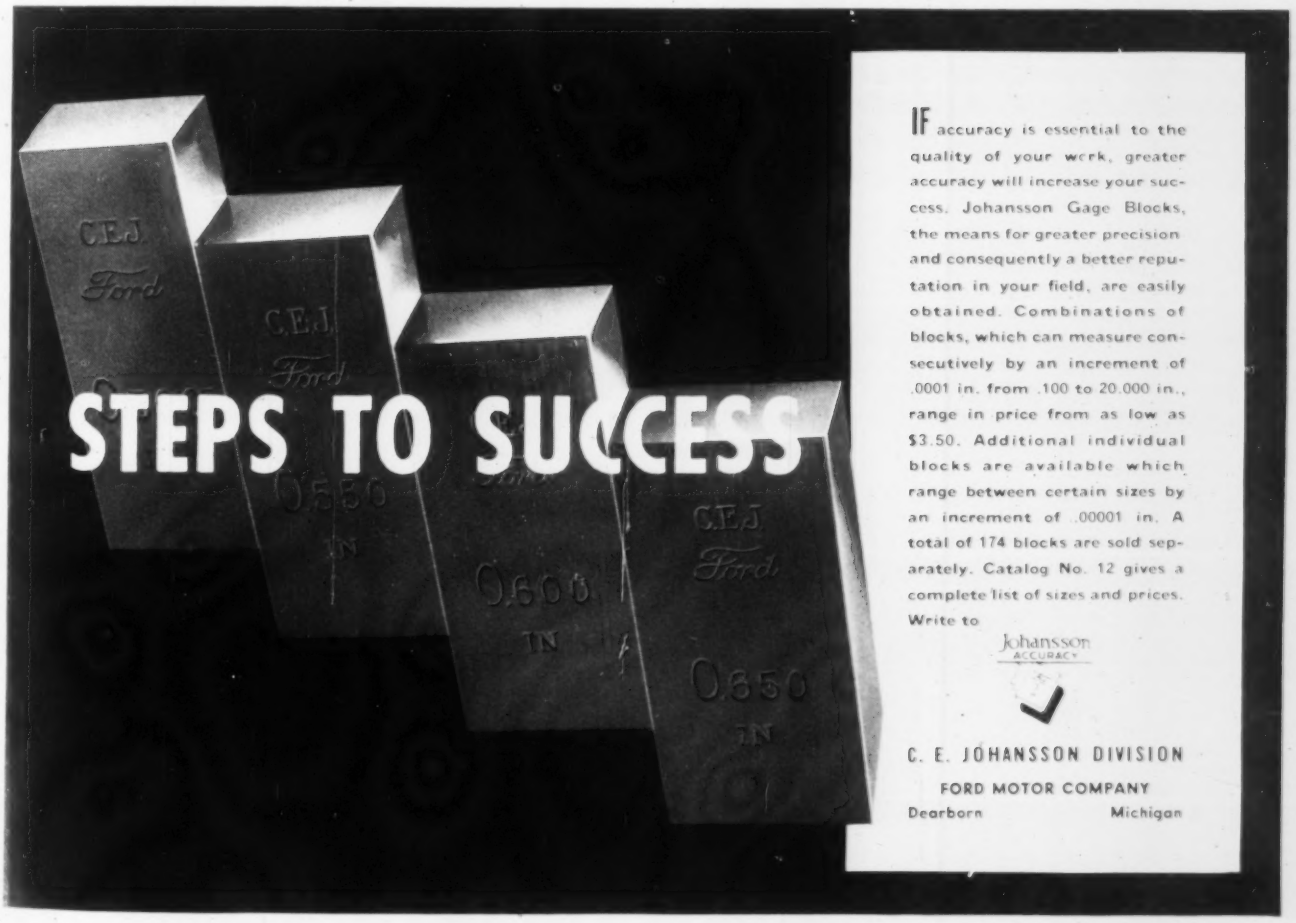
Honorable Mentions to:

W. C. Gardiner, Niagara Falls, N. Y.;
Don Greenwell, Rochester, N. Y.;
W. E. Wenger, Philadelphia, Pa.;
John F. Black, Raleigh, N. C.

All four use capillary devices. The first two measure the height of methanol column above orifice; the latter two *weigh* the small quantity of methanol *above the* dripper. Wenger passing the methanol inside a vertical glass tube and using a spring balance, Black sliding the methanol drops *outside* his inclined glass tube and using a laboratory equal-beam balance. All four ideas seem to lack the specified 17:1 rangeability; all would require delicate parts to be satisfactorily accurate. Greenwell writes that he first tried his scheme before writing but he, too, fails to mention accuracy.

Honorable Mention to E. M. Fry, Jr., Roselle Park, N. J., for a combination of (1) small positive metering pump, (2) shunt-wound variable speed a.c. motor, (3) tachometer generator, (4) recording electrical instrument connected to generator and serving as flow-rate recorder, (5) photoelectric relay, (6) electronic type of automatic motor speed controller, (7) mercury-in-glass manometer suitable for use with photoelectric relay. Ingenious but fails to win cash award because of high first cost, probably high running expenses, possibility of too-frequent shut-downs . . . and uncertainty as to probable accuracy.

The tenth entry proposed an ordinary thin-plate orifice meter "and with taps about six diameters upstream and downstream" and with mercury manometer" and with visually read scale! The entrant had won a $5 prize last year but this time he missed out by a mile. We haven't time to compute exactly, but as a rough guess we'd say that even the maximum differential (drawing shows a 0.30 ratio of orifice diameter to pipe diameter and apparently a 4" pipe) would be less than the error of observation. It's too bad, because the entrant wrote a useful dissertation on metering practice, advising removing burrs from pressure-tap drill-holes, and so on. He just didn't realize that "0.3 lb. hr." means about one drop per second.



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